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# SHALL WE USE LIVE PETS IN THE SCIENCE ROOM?

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Teachers of elementary science often hesitate to use live animals in the classroom. Many reasons contribute to their hesitancy—lack of knowledge and experience with animals; the problem of week-end care; the lack of proper cages; the possible odor; and perhaps the question as to the real educational value to the children.

There are several reasons why the study of animals is furthered by having the live specimens where the children can care for them and observe their habits. When I came to the Museum of Natural History four years ago, I decided to try to demonstrate some of these values. Previously the Museum teachers had depended almost entirely on the mounted specimens from

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Miss Curry has an excellent background of college work at Western Reserve University, Cleveland, Ohio, and at the University of Colorado, Boulder, Colorado, which makes her thoroughly at home in teaching the many phases of natural science asked for by the teachers. She frequently helps teachers conduct field trips to the Metropolitan Parks where her knowledge of geology, wild flowers, and the wild life of the woods greatly enriches the experiences of the pupils.

During the summer, Miss Curry is in charge of the Trailside Museum in Rocky River Park, near Cleveland.

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the Museum's collection. The children from the Cleveland Public Schools visit the Museum for lessons which correlate with the classroom program or enrich their experiences in the field of science.

The interest of the children in the live pets has more than justified the experiment. After the first year the classes that returned for a second or third visit always asked about the pets, recalled most of the facts developed with the live specimens and were anxious to see the new pets. Since we had named the pets, they became real personalities. The children asked, "How is Fibber?" and not, "How is the owl?"

More valuable than the definite information about the habits of the various animals are the attitudes developed.

My most valuable pet in overcoming fear is my five-foot pilot black snake. When the snake is first taken out of its cage, the natural reaction of a class is one of fear and dislike. I usually put the snake around my neck and casually begin to talk about it, trying to substitute the true and interesting facts for the false and weird stories on which most people are brought up. We talk about the snake's method of feeding, of shedding its skin, how it can move without legs, why the forked tongue goes in and out, how poison snakes inject their poison, and, of course, the fact that snakes do not feel slimy. During the discussion the class begins to relax, since nothing dreadful seems to happen to me as the snake crawls around my neck. Eventually the children are leaning forward to get a better look. This is a good time to let the class feel the snake to prove to themselves that it is not slimy. Usually almost every child will feel it and the next question is, "May I hold it?" The snake is then passed around, and it is interesting to watch the expression of satisfaction and achievement. They feel that they have really accomplished something and so they have, for they have overcome a fear and prejudice handed down for generations. We always end a discussion of snakes by pointing out the four poisonous types in the United States and the danger involved. There are also directions given as to how to catch and hold a snake (behind the head) until one is sure it is tame enough to allow it freedom. Children learn to appreciate snakes and understand that they have their place in the scheme of things.

This idea of the place of animals in nature is the thought left with the children after every observation.

When I exhibit my pet skunk, the instinctive reaction of the

children is to laugh, hold their noses, or back away from the animal. When I assure them that our skunk has had its scent glands removed, the aversion begins to abate. When they learn that they feed partly on mice and grubs, they realize that skunks are beneficial. Next comes the fact that skunks are rather slow moving, deliberate animals and so it is necessary for them to protect themselves with the scent. By this time, the children are eager to pet the skunk.

In any environment there are many animals which the children do not see because they are nocturnal. Our flying squirrels illustrate this point because both children and teachers are surprised to find they inhabit our Ohio woods. They are also surprised that any squirrel is as small as that and insist they must be babies. Through observation, the children discover that they have no wings and consequently cannot "fly" but that the flap of skin between the front and back legs and the flat tail make them good gliders.

Fox squirrels, who love to sit up and eat peanuts, make a good starting point for a discussion of the gnawing teeth of the rodent group.

A very tame and friendly barn owl, who obligingly eats mice or horse meat for the classes, illustrates far better than any words or mounted specimen, the value of the talons for catching and the hooked beak for tearing the prey. The food habits are a concrete illustration that most of our hawks and owls are beneficial and should be protected.

Our pet crow eats meat or insects to prove that a crow's diet is not entirely grain and that therefore they are not the menace that farmers have always thought.

How many times we have heard children warned not to pick up toads! The old superstition about toads giving warts is soon overcome if children have a pet toad. Watching a toad eat never fails to interest them. Even though they never can actually see the sticky tongue dart out to get a tempting meal worm, they do see the worm disappear. As one boy said, "It's just like a magnet."

Some wild pets should not be kept long in captivity, but if the opportunity comes to keep a young raccoon, woodchuck, opossum, skunk, or squirrel for a while, it is a valuable experience. To make a pet of any animal it should be taken very young before it has learned to depend on itself for food. If a young animal is fed and handled by a person, it usually becomes tame and

friendly. Until one has become acquainted with any new wild pet, it is wise to use heavy gloves in handling it. Children should be cautioned not to disturb an animal while it is eating.

Having the live animals stimulates an interest and a desire to get more information. The interest may later develop into a hobby for a leisure time activity. I have known several boys whose interest in animals as pets has led to real scientific study in later years. City children have so little opportunity to become acquainted with the native animals that it is a challenge to the schools to present them as one phase of our environment. Knowledge leads to the appreciation of the economic as well as aesthetic values of the living things that make up life on the earth.

Children develop a sense of responsibility when they assume the care of the pets. They can plan committees to take care of the various needs of the animals, such as cleaning the cages, feeding, washing the feeding dishes, and buying or securing the various types of food. If these committees are rotated, the children do not become tired of one job.

When children have the actual care of the pets they learn many interesting facts from close daily observation. Becoming acquainted with animals creates an interest and love for them so that "lessons" on kindness to animals are not necessary. Try keeping two or three live pets and see if you, too, are not convinced that they have an educational value.

A later article will give specific suggestions as to the care of various animals.

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## RUSSIA'S NEW DNIEPER HYDROELECTRIC PLANT EQUIPPED WITH AMERICAN GENERATORS

Russia's gigantic hydroelectric plant on the Dnieper river in the Ukraine is in operation again, after a nearly six-year interval since its destruction in 1941 by the Soviet troops to prevent its use by Hitler's Nazis.

The new equipment is American-built. The first of three new General Electric generators has now been successfully operated at full speed, it is revealed, and the other two are far advanced in assembly.

GE engineers state that the new generators are the largest ever built, being 90,000-kva, the kilovolt-ampere unit of power which is equal to 1000 volt-amperes. They will be driven by three 100,000-horsepower hydroelectric turbines built by the Newport News Shipbuilding and Dry Dock Company.

Rebuilding the Dnieper Dam was begun in 1944 by Soviet Union engineers and workmen soon after the Nazi forces had been driven back. It will have greater power-generating capacity than before, although it was rated in prewar days as Europe's largest hydroelectric dam.

# MORE FUN WITH CONICS

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The following optional project was given to a group of intermediate algebra students a short while ago:

"Plot the following carefully on the same axes. To facilitate computation, do not clear of fractions or expand. For example, in equation *5*, solve for $\frac{2}{5}(x+7)$, from which $x$ can be obtained easily. Number *13* is a little difficult. When a value for $x$ has been substituted, an unattractive quadratic in $y$ results. With the quadratic formula and a slide rule or a table of powers, roots, and logarithms, the values of $y$ can be computed quickly.

1. Plot

$$\frac{x^2}{36}+\frac{y^2}{16}=1$$

for values of $y>-2$

2. Join $(5.2, -2)$ with $(-5.2, -2)$
3. Plot

$$(x-3)^2+(y-\tfrac{1}{2})^2=\tfrac{25}{4}$$

for values of $x<\frac{5}{2}$

4. Plot

$$(x-6\tfrac{1}{2})^2+(y+\tfrac{1}{2})^2=\tfrac{9}{4}$$

Do not cross curve of number *1* to left.

5. Plot

$$\tfrac{4}{25}(x+7)^2+\frac{y^2}{4}=1$$

for values of $x<-5.5$

6. Plot

$$(x+7)^2+\frac{4(y-5)^2}{49}=1$$

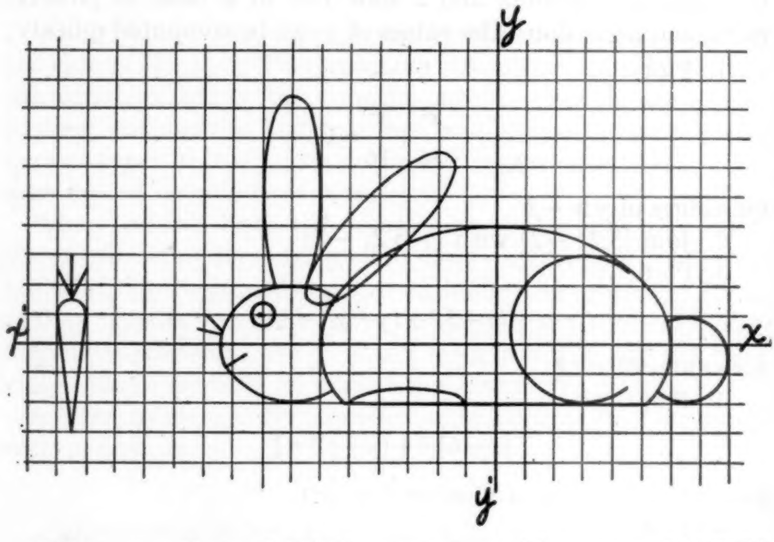
for values of $y>1.9$

7. Plot

$$\frac{(x+3)^2}{4}+4(y+2)^2=1$$

for values of $y > -2$

8. Plot $(x+8)^2+(y-1)^2=.16$
9. Plot the point $(-8.1, 1)$
10. Join $(-9.3, -.8)$ and $(-8.6, -.4)$
11. Join $(-9.3, .5)$ and $(-9.9, 1)$
12. Join $(-9.4, .4)$ and $(-10.3, .5)$
13. Plot $53x^2-90xy+53y^2+784x-784y+3038=0$
14. Plot $(x+14.5)^2+(y-1)^2=\frac{1}{4}$ for values of $y>1$
15. Join $(-14, 1)$ and $(-14.5, -3)$
16. Join $(-15, 1)$ and $(-14.5, -3)$
17. Join $(-14.5, 1.5)$ with each of the following three points: $(-14, 2.5)$ and $(-14.5, 3)$ and $(-15, 2.5)$




When you have finished, may we wish you a HAPPY EASTER!"

Any good student in an intermediate class can do this graphing. The individuals who carried the project to completion took pleasure in it, partly because of the puzzle element and partly because they enjoy conics. They learned in effortless fashion something of standard forms of the circle and ellipse, translated from the origin. Many excellent questions arising from this project were asked and a lively discussion took place.

For a fuller account of how this type of material can be used as a teaching device see "Conics Are Fun," SCHOOL SCIENCE AND MATHEMATICS, December, 1945.

# FACTORS CONTRIBUTING TO THE DEATH OF SUBMERGED COLEUS

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## Introduction

The fact that many plants in the field and in the laboratory suffer markedly from inundation by water is well known. This phenomemon is frequently attributed to suffocation due to lack of oxygen. To demonstrate the effect of suffocation in plants, many botany courses use coleus plants which have been submerged in water in a battery jar. Usually after several weeks the leaves decay and drop off, the stems become discolored, and the plants appear to die. In this laboratory, one such demonstration plant was by accident left for over three months. The appearance of renewed growth stimulated investigations by the writer during 1940 and 1941. The analysis of the data and final summarization has been delayed until the present by the war.

## The Phenomena Preceding Death of Submerged Coleus

Observations made of a series of over thirty coleus (*Coleus Blumei* Benth.) plants—some potted, some with soil removed from the roots, some mere cuttings, but all submerged in aquaria and battery jars—yielded the following general pattern of events leading to death as a result of submergence (Table I):

Table I. The Usual Succession of Events Leading to Death of Coleus Plants when Submerged in Tap Water in Aquaria

| Stages in Death | Length of Time of Submergence |
|---|---|
| Abscission of large leaves | 2–3 weeks |
| Formation of adventitious roots | 3 weeks |
| Formation of axillary leaves | 3–4 weeks |
| General discoloring of plants | 8–10 weeks |
| Complete decay of plants | 10–15 weeks |

The usual classroom demonstration considers only the first stage in this sequence—the abscission of the leaves, and explains the cause of death as suffocation. The data in Table I show that the phenomenon so explained is not death (of the entire plant) at all; however, as the (whole) plant does finally die, there is

still the problem of the ultimate cause of death. The following data are a summary of some of the evidence accumulated to date to help clarify this point.

### Oxygen Content of Water Surrounding a Submerged Coleus

In order to determine whether the presence of the plant in

Fig. 1. Coleus plant after seven weeks of submergence in water, showing the adventitious roots, new stem growth, and the small leaves. (Photograph by A. Vatter, through wall of aquarium.)

water affected the concentration of dissolved oxygen, a series of determinations of dissolved oxygen concentration was made over a period of thirteen days on water surrounding a submerged coleus. The Winkler method, as outlined in the *Standard Methods for the Examination of Water and Sewage* (Amer. Pub. Health Assoc., 1933), was employed upon 400 ml. samples.

TABLE II. DETERMINATIONS OF DISSOLVED OXYGEN CONCENTRATION IN WATER SURROUNDING A SUBMERGED COLEUS PLANT OVER A PERIOD OF THIRTEEN DAYS

| Date | Time of Day | Dissolved Oxygen Concentration, ppm. |
|---|---|---|
| Original tap water | — | 5.3 |
| Nov. 7, 1941 | 9:30 A.M. | 7.2 |
| Nov. 7, 1941 | 5:30 P.M. | 7.2 |
| Nov. 10, 1941 | 2:30 A.M. | 7.2 |
| Nov. 12, 1941 | 12:30 A.M. | 7.2 |
| Nov. 20, 1941 | 9:30 A.M. | 7.2 |

These data indicate that the concentration of dissolved oxygen was unchanged day or night during the period of time after it had reached equilibrium with the atmospheric conditions of the laboratory.

## DIFFUSION OF GASES BETWEEN PLANT AND WATER

To determine whether gases diffuse between coleus leaves and surrounding water, Gessner's (1938) method, as employed with aquatic plants, was used to show changes in dissolved oxygen concentration of the water in the vicinity of submerged coleus leaves. Four 200 ml. Ehrlenmeyer flasks were prepared with partially deaerated water (Wood, 1941), and two large leaves, which had been allowed to stand for one hour in similarly treated water in order to bring them into gaseous equilibrium with that medium, were placed in each flask. The flasks were anaerobically stoppered, and two were placed in the dark box

TABLE III. CHANGES IN DISSOLVED OXYGEN CONCENTRATION IN DEAERATED WATER IN ANAEROBICALLY STOPPERED FLASKS CONTAINING COLEUS LEAVES OVER A PERIOD OF 5 HOURS, TWO IN DARK AND TWO UNDER ARTIFICIAL LIGHT

| Flask Treatment | Dissolved Oxygen Concentration, ppm. | Deviation from Control |
|---|---|---|
| Control | 1.8 | — |
| Leaves kept in light | 2.4 | +0.6 |
| | 2.0 | +0.2 |
| Leaves kept in dark | 1.4 | −0.4 |
| | 0.8 | −1.4 |

and two placed 50 mm. from a 60 watt, tungsten Mazda bulb. The temperatures were maintained constant and equal by water baths. After five hours, determinations of the dissolved oxygen concentrations were made on each. These data are summarized in Table III.

It is indicated from these data that a very significant reduction in oxygen concentration occurred in the dark; whereas a less marked increase occurred in the light. The apparent discrepancy between the data in Tables III and II may need clarification. In the open battery jar no change of oxygen concentration was found, whereas in the closed flasks marked changes were found. This is to be explained by the relatively small amount of plant material in the battery jar in relation to the volume of water and the fact that it was open to the atmosphere with which an equilibrium was maintained. On the other hand, in the closed flasks a large amount of plant material was placed in a relatively small volume of water and the vessel stoppered to prevent equilibrium with the atmosphere. It is shown, however, that gases (oxygen in this case) diffuse between the water and the plant; and thus in our main experiment it may be considered that at least some oxygen in the water is available to the coleus plant.

To determine whether carbon dioxide diffuses into plants or if bicarbonates are available from water, a colorimetric technique was developed. Four 60 ml. glass cylinders were prepared by filling them with a partially deaerated (to remove free $CO_2$) 0.1% $NaHCO_3$ solution. To each of these, 5 drops of universal indicator (Loomis and Shull, 1937, p. 446) were added. A pair of opposite coleus leaves, similar in all ascertainable respects, were rinsed in deaerated water, then placed in two of the four cylinders. In each set of experiments, one control and one experimental cylinder were placed in the dark box, and a similar set was placed under a 1000-watt bulb. Temperature was controlled by water baths. The data are summarized in Table IV.

These data indicate that the solution surrounding the submerged leaves exposed to light increased in *p*H, while those in the dark, as well as the controls, did not increase measurably. Thus, the increase in *p*H indicates that the alkalinity had been increased by the removal of carbon dioxide from solution into the plant. It further indicates that half-bound carbonates in

TABLE IV. EFFECT ON $CO_2$ CONTENT OF 0.1% $NaHCO_3$ SOLUTION SURROUNDING SUBMERGED COLEUS LEAVES IN LIGHT AND DARK, AS INDICATED BY *p*H CHANGE BY UNIVERSAL INDICATOR

| Conditions | Color Changes | *p*H Changes |
|---|---|---|
| Leaves in dark | No color change | No measurable increase |
| Control in dark | No color change | No measurable increase |
| Leaves in light | Amber to green | *p*H increased |
| Control in light | No color change | No measurable increase |

water are available to the plants, since their concentration was actually reduced in the surrounding solution.

## CHANGES IN STARCH CONTENT OF LEAVES

To determine the relative rate of change of starch content in the leaves, three sets of two comparable coleus plants of the same age, general conditions, stock, and history were chosen. One plant of each set was placed in the dark box, and the other was submerged in a battery jar of water and placed in the light. One similarly situated leaf was taken from each plant each successive day after the above treatment was begun, and the iodine test, as a starch indicator, was carried out. The data are summarized in Table V.

TABLE V. THE RELATIVE AMOUNT OF STARCH IN LEAVES OF COLEUS PLANTS ON SUCCESSIVE DAYS AFTER 1) SUBMERGING BUT KEEPING IN LIGHT, AND 2) KEEPING IN AIR BUT IN DARK BOX

| Number of Days After Set Up | Presence of Starch in Leaves | |
|---|---|---|
| | Plant Submerged but Kept in Light | Plant in Air but Kept in Dark Box |
| 1 | abundant | abundant |
| 2 | abundant | abundant |
| 3 | weak test | weak test |
| 4 | only in veins | only in veins |
| 5 | absent | absent |

These data indicate that the starch disappeared at the same relative rate from comparable leaves of coleus plants when the plants were submerged in water but kept in light and when the plants were kept in air but in dark box. Thus, the factors in both cases appear to be the same; and if so, ultimate death could not be due to the lack of oxygen (suffocation), for the plant in the dark box was in ordinary atmosphere.

### Effect of Submergence on Various Types of Leaves

In order to determine what effect the condition of the leaf has on its response to submergence in water, a number of coleus stem cuttings were immersed in a large aquarium. These cuttings had been treated in the following ways: (1) some were used without further treatment, (2) some had only the large leaves removed, (3) some had all leaves removed, and (4) some were taken from plants which had been etiolated by having been kept in a dark box for nearly a month, and had formed small, white, unfolded leaves. The data in Table VI summarize the results after various lengths of time of immersion.

Table VI. Response of Various Types of Coleus Leaves when Submerged in Water

| Type of Cuttings | Results after Submergence for Various Lengths of Time |
|---|---|
| Cuttings with normal leaves | Leaves abscised within 2 weeks |
| Cuttings with small leaves | Leaves continued to grow |
| Cuttings with leaves removed | Axillary stems and leaves developed after 5 weeks |
| Cuttings with etiolated leaves | Leaves unfolded, turned green, and enlarged |

These data would indicate that whatever the direct cause of abscission was, only the old leaves responded when submerged. The growth of small leaves, development of buds into stems and leaves, and chlorophyll synthesis in etiolated leaves indicate that respiration was in progress. The mere development of chlorophyll, as well as respiration, would again indicate availability of oxygen from water.

In order to determine whether the oxygen, which was utilized in chlorophyll synthesis in the etiolated leaves, might have been derived from residual oxygen remaining in the intercellular spaces present prior to immersion, tests were run upon etiolated bean (*Phaseolus vulgaris* Linn.) seedlings by immersion in vessels of water solutions of air, nitrogen and carbon dioxide. These solutions were prepared by continuous bubbling of air, nitrogen, and carbon dioxide through the water during the experiment. After four days, the bean seedlings in the aerated water had developed chlorophyll and were healthy,

while those in the carbon dioxide and nitrogen-treated waters had failed to develop any chlorophyll and had died. These data indicate that (1) chlorophyll synthesis occurred only in water containing oxygen, (2) residual oxygen in the intercellular spaces was inadequate to support chlorophyll synthesis when the plant was exposed to light, and (3) the plants died unless oxygen was present in the water.

### Comparison of Effects of Darkness and Submergence on Coleus

In order to further test the apparent similarity between response of coleus plants to submergence on one hand and keeping in dark (in air) on the other, the following technique was

A. B. C. D.

FIG. 2. Plants representing four stages in the sequence of events leading to death of coleus when submerged. A. Submerged 2 days, with plant intact. B. Submerged 14 days, with large leaves abscising. C. Submerged 25 days, with small leaves beginning to develop. D. Submerged 38 days, with stems, small leaves, and adventitious roots developed. The final stage of death is not shown. (Photograph by A. Vatter, through wall of aquarium.)

employed. Three sets of two comparable potted coleus plants were selected. One plant of each set was placed in a battery jar sufficiently full of water to cover half of the leaves. The second was enclosed in a cardboard box so that the leaves on the lower half of the plant were kept in the dark (comparable to immersed leaves of the first plant), and the leaves on the upper

half of the plant were left exposed to light. In both cases, the majority of upper exposed leaves was unaffected; the leaves that did abscise were only those very close either to the surface of the water or to the top of the dark box. On the other hand, all the large leaves that were either submerged or in the dark box abscised, and small stems and leaves developed in the axils. Thus, in the two cases, the response to submergence and darkness was apparently identical.

In the above plants, adventitious roots developed upon the submerged half of the one plant but not upon the darkened half of the other. This was shown to be due to the reduced humidity as a limiting factor by placing the half-darkened plant under a bell jar with an open vessel of water so that the relative humidity was at a maximum. After a few days, adventitious roots began to develop.

Thus, it has been shown that effects of darkness and submergence on coleus plants were comparable in the following ways:

1. Submerged leaves in light and aerial leaves in darkness lost starch at about the same rate (Table V).
2. Aerial leaves in the dark and submerged leaves in light abscised.
3. Small leaves developed in the axils of the abscised leaves in both cases.
4. New stems bearing foliage developed in both cases.
5. The plants died after about the same length of time.
6. Both developed adventitious roots (if aerial plant is subjected to sufficiently high relative humidity).

## Discussion

A study of the above experiments and phenomena suggests possible factors contributing to the ultimate death of submerged coleus plants.

*Death from Suffocation.* This explanation, based on the popular idea that a submerged coleus plant would deplete the available dissolved oxygen, seems quite untenable for the following reasons: (1) although oxygen concentration of water is often influenced by biotic factors, in this case, it is in dynamic equilibrium with the oxygen of the atmosphere and was not depleted by the presence of the plant, as is borne out by the fact that successive determinations on water surrounding a submerged plant were practically constant over a period of thirteen days; (2) diffusion of oxygen occurred between submerged leaves and water, so that if oxygen is present, it will be available to the plant at least in some quantity; and (3) the

plants actually showed continued growth and initiated new growths in a submerged condition for many weeks.

*Death from Starvation.* This less popular explanation has the backing of most of the evidence uncovered by the present work.

(1) Submerged plants exposed to light and aerial plants kept in the dark responded similarly in all ways observed, including rate of leaf abscission, development of adventitious roots, and development of axillary stems and leaves.

(2) The rate of loss of starch in the two cases was comparable. A possible interpretation of factors which might result in such phenomena may be as follows:

(a) The greatly reduced available oxygen in water as compared with the atmosphere would reduce respiration in sensitive parts of the plant, and such disturbances result in the abscission of the large leaves.

(b) Meristematic and young tissue, which are still vigorous and capable of enduring a new medium, develop within the limits of the new factors; such factors appearing to limit the growth only to small leaves and stems.

(c) The reduced amount of photosynthesis which occurs in the relatively very small "aquatic" leaves is insufficient for the metabolic processes of the plants or cuttings, and reserve foods are utilized by the plant. It is felt that when these reserve foods are no longer available in sufficient quantity to supplement the small amount produced by the leaves, the plant dies.

*Death from Other Complications.* Although it has been shown that reduced oxygen availability does not eliminate the metabolic processes in submerged leaves, it is recognized that this reduction in oxygen might possibly have other lethal effects of a more intricate nature. Among these possibilities might be disturbance of certain physiochemical equilibria, enzymatic systems, and "blocking" of synthetic processes.

## Summary

1. It is shown that the concept that a coleus plant dies in two to four weeks when submerged in water is erroneous. This mistakenly interpreted phenomenon is shown to be but the first in a much longer sequence of events leading to death. The actual pattern includes loss of leaves in two to four weeks followed by development of leaves, stems, and adventitious roots, with death occurring only after ten to fifteen weeks.

2. The dissolved oxygen concentration in the water surround-

ing the plants was not depleted but remained practically constant night and day for thirteen days, apparently in equilibrium with the atmosphere.

3. Oxygen was shown to diffuse between water and the leaves of coleus, and dissolved oxygen in water was essential to chlorophyll synthesis in submerged etiolated leaves.

4. Bicarbonates (presumably as $CO_2$) were shown to be available to submerged coleus leaves.

5. Starch was lost from leaves of coleus in the dark (not submerged) at about the same rate as from leaves of plants submerged but kept in the light. Further, both plants followed the same general pattern of phenomena leading to death except for the development of adventitious roots. These, however, were shown to develop in the aerial plant when sufficiently high relative humidity was maintained.

6. Causes of death in submerged coleus are much more complex than merely a matter of suffocation. It is suggested that the cause is more directly attributable to starvation.

ACKNOWLEDGMENT

The investigations were conducted under the guidance of Dr. R. O. Freeland, Department of Botany, Northwestern University.

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## POST WAR INSTRUMENTS

A 96-page supplementary catalog containing post-war improvements and new instruments is available. Included are: A new spectrometer reading directly in wave lengths to 20 Angstroms with both prism and grating; A new standard weather bureau mercurial thermometer; A 12-inch dial aneroid barometer again is available; Two new Duo-Seal vacuum pumps; New electrical measuring instruments; A new acid pump; 1947 Edition of the Hubbard Chart of the Atoms; A Chart of Organic Chemistry; A Chart of Atomic Structure; and improved designs evolved during the war years. W. M. Welch Manufacturing Company, 1515 Sedgwick Street, Chicago 10, Illinois.

# SOME SIDELIGHTS FOR THE ARITHMETIC TEACHER

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To teach well, the teacher must have a background of "marginal" information and understanding. Such a background is not to be regarded primarily as a reserve to be drawn upon readily should the occasion arise, although this secondary role is not without significance. Fundamentally the reasons for insisting that the teacher shall "know far more than she expects to teach" concern the subtler qualities of her instruction—its seriousness, its depth, its resourcefulness. This additional insight and appreciation will have to do with the history and evolution of arithmetical symbols, processes and concepts; with the philosophy, logic and mathematics of arithmetic; with the cultural and humanistic bearings of arithmetical knowledge; with the psychology and sociology of learning arithmetic; and with the socio-economic significance of arithmetic skills and understandings.

From one point of view, arithmetic is a very old subject. Presumably, primitive man had learned to count long before history recorded the arithmetical achievements of the pre-Babylonian and Egyptian cultures, and long before the Greeks apologetically busied themselves with the art of computing (*logistica*) while cultivating with greater zeal the art of numbers (*arithmetika*). From another point of view, however, our number system, and the methods of computation as we know them today, are relatively modern—almost as young as "modern science." We need only recall that our present notation for decimal fractions did not come into general use until about 1600 or later, and that the counting board had begun to disappear only half a century earlier. The logical foundations of arithmetic were not established until the close of the 19th century; that is, not until then was it shown that propositions of arithmetic, as a formal body of doctrine concerning numbers and the operations by which numbers may be combined, are deducible from a few assumptions.

How may such perspectives and backgrounds be attained? Several ways readily suggest themselves. One may cultivate the habit of perusing professional and scholarly journals, where many and illuminating or suggestive articles will be found.

Again, one may browse through certain books, such as Dantzig's *Number, the Language of Science;* Hogben's *Mathematics for the Million;* Bakst's *Mathematics, Its Magic and Mastery;* L. E. Boyer's *Mathematics for Teachers;* Hooper's *The River Mathematics;* and Kasner and Newman's *Mathematics and the Imagination*, to mention a few outstanding ones. Not infrequently, however, some excellent periodical article fails to receive the widespread recognition which it merits; or a book which has something to offer the arithmetic teacher may perchance give the impression of being overly technical or too erudite, and thus fails to invite the attention which it deserves. Sometimes, indeed, the most stimulating ideas lie buried in some out of the way place where they completely escape attention. Very often a brief passage gleaned from such sources may serve to inspire the teacher, suggest new ideas, deepen her insight, or renew her faith. It is with these thoughts in mind that the following "sidelights," gleaned from here and there, are offered with the hope that they may serve such purposes. Many others could have been included, but these few must suffice. Any inadequacies are to be attributed solely to the shortcomings of the compiler. Grateful acknowledgement is here made to the many publishers of the works from which these gleanings have been gathered.

In the French Revolution, when called before the tribunal and asked what useful thing he could do to deserve life, Lagrange answered: "I will teach arithmetic."

—G. B. Halsted: *On the Foundation and Technic of Arithmetic*, p. 1

Arithmetic is usually regarded as the Cinderella of Mathematics, the drudge whose duty it is to do everything that is dull.

—Herbert McKay: *Odd Numbers* (Preface)

Arithmetic, because of its service to the individual and to society as well, continues to occupy a significant position in the curriculum of the elementary school. In general, the curricular problems pertaining to arithmetic are similar to those of a decade and a generation ago. They originate with the recognition that arithmetic is important in the lives of intelligent citizens and with the observation that many of our recent graduates from the public schools are not competent in simple mathematical situations.

—Ben A. Sueltz: *Arithmetic in General Education*, p. 20

The miraculous powers of modern calculation are due to three inventions: the Arabic Notation, Decimal Fractions and Logarithms.

—F. Cajori: *History of Mathematics*, p. 161

In the history of culture the discovery of zero will always stand out as one of the greatest single achievements of the human race.

—T. Dantzig: ***Number, the Language of Science***, p. 35

This invention of something to represent nothing is a stroke of genius which can scarcely be overpraised. Upon the insignificant zero, symbol for nothing, rests the whole of mathematical science. Without it, no number system was possible without the introduction of ever new and more numerous symbols for large quantities. Without it, all our present mathematical short-cuts of multiplication, division, decimals, logarithms, could not have been invented.

Many people have assumed, without really thinking it through, that it is the base of ten in our number system which gives it these mathematical advantages. It will be obvious that this is not the case. The Romans had a number system based on ten, and we have seen how mathematically useless it was. The early Egyptians had a number system based on ten, and it even embodied grouped symbols which were nearly the equivalent of separate numerals (see Fig. 1); but they made the fatal mistake of having a separate new symbol for ten instead of a zero, and were able to represent two tens only by repeating this symbol. It was the invention of the zero, not its attaching to any particular number base, which at one leap raised numbers from mere symbols for quantities to symbols capable of use in intricate calculations.

—F. Emerson Andrews: ***New Numbers***, pp. 27–28

Arithmetic is far from being a childish topic. Students of calculus are frequently hampered by ignorance of the laws of number.

—J. H. Moore, and J. A. Mira: ***Practical Business Mathematics***, p. v

The history of arithmetic shows that the ideas of number have had a long slow growth in the history of the race, and that the completed development of our present notation, or method of writing numbers, is relatively modern. Stages of human culture may be judged by the attainment achieved in the mastery of the mathematical ideas.

—E. H. Taylor: ***Arithmetic for Teacher-Training Classes***, p. 1

It may come as a surprise to many people that our number system, which we take for granted as if it was part of the Creation, is actually less than half as old as Christianity, is younger than Mohammedanism, was entirely unknown to Charlemagne, is newer (so far as general European acceptance goes) than the Magna Carta. Firmly entrenched though it seems, it has been in use less than half as long as the period in which Roman numerals flourished as civilization's sole number system.

—F. Emerson Andrews: ***New Numbers***, p. 30

The technique of measurement and counting has followed the caravans and galleys of the great trade routes. It has developed very slowly. At least four thousand years intervened between the time when men could calcu-

late when the next eclipse would occur and the time when men could calculate how much iron is present in the sun. . . . Civilizations have risen and fallen. At each state a more primitive, less sophisticated culture breaks through the barriers of custom thought, brings fresh rules to the grammar of measurement, bearing within itself the limitation of further growth and the inevitability that it will be superseded in its turn. The history of mathematics is the mirror of civilization.

—L. Hogben: *Mathematics for the Million*, p. 32

The validity of mathematical reasoning is due not to the nature of things but to the nature of thinking.

—C. H. Judd: *Educational Psychology*, p. 307

The new mathematics is a sort of supplement to language, affording a means of thought about form and quantity and a means of expression, more exact, compact, and ready than ordinary language. The great body of physical science, a great deal of the essential facts of financial science, and endless social and political problems are only accessible and only thinkable to those who have had a sound training in mathematical analysis, and the time may not be far remote when it will be understood that for complete initiation as an efficient citizen of one of the great new complex world wide states that are now developing, it is as necessary to be able to compute, to think in averages and maxima and minima, as it is now to be able to read and write.

—H. G. Wells: *Mankind in the Making*

If anyone thinks he has no use for arithmetic let him consider the number of comparisons he makes every day. . . . We are always making comparisons, well or ill, accurately or inaccurately; one of the virtues of arithmetic is that it enables one to make comparisons neatly and accurately.

—Herbert McKay: *Odd Numbers*, p. 61

Until comparatively recent years nobody but mathematicians had occasion to deal with very large numbers as a rule. With world-wide wars and the attendant enormous costs, met to some extent by your income tax and mine, all of us are now only too familiar with words like "million" and "billion."

—A. Hooper: *The River Mathematics*, p. 15

The man of the machine age is a *calculating* animal. We live in a welter of figures: cookery recipes, railway time-tables, unemployment aggregates, fines, taxes, war debts, over-time schedules, speed limits, bowling averages, betting odds, billiard scores, calories, babies' weights, clinical temperatures, rainfall, hours of sunshine, motoring records, power indices, gas-meter readings, bank rates, freight rates, death rates, discount, interest, lotteries, wave lengths and tyre pressures. . . . Ratios, limits, acceleration, are not remote abstractions, dimly apprehended by the solitary genius. They are photographed upon every page of our existence.

—L. Hogben: *Mathematics for the Million*, p. 16

Averaging is perhaps the best known of all the secondary arithmetical processes. The method is so simple: you merely add a few quantities and divide the sum by the number of quantities. Even textbook writers do not quite succeed in making the process difficult. They do their worst, but the method remains obstinately simple.

Perhaps because of its simplicity, and the nice air of mathematical certitude about the result—an appearance of exactness obtained by the mere process of dividing—averages have an almost universal appeal. Averaging is the most popular of all arithmetical processes. And the most delusive.

—Herbert McKay: *Odd Numbers*, p. 113

In Mathematics, Woman leads the way:
The narrow-minded pedant still believes
That two and two make four! Why, we can prove,
We women—household drudges as we are—
That two and two make five—or three—or seven;
Or five-and-twenty, if the case demands!

—Gilbert and Sullivan: *Princess Ida*, Act II

Man, even in the lower stages of development, possesses a faculty which, for want of a better name, I shall call *Number Sense*. This faculty permits him to recognize that something has changed in a small collection, when without his direct knowledge, an object has been removed from or added to the collection.

—T. Dantzig: *Number, The Language of Science*, p. 1

Another factor of intelligence that is quite easily identified has been called the number factor *N*. This is represented by facility in doing simple numerical tasks, but it must not be inferred that this factor is heavily involved in arithmetical reasoning or in mathematics. One should not be surprised to find some very competent mathematicians, who are not high in the number factor *N*. On the other hand, one should expect to find a good cashier or bookkeeper to have facility in this factor. Arithmetical reasoning, which is represented by the familiar statement problems in arithmetic, involves a number of other factors often more important than number facility *N*.

—L. L. Thurstone: *Theories of Intelligence*, Scientific Monthly, Feb. 1946, pp. 106–107.

The idea of number is not impressed upon the mind by objects even when these are presented under the most favorable circumstances. Number is a product of the way in which the mind deals with objects in the operation of making a vague whole definite. This operation involves (a) *discrimination* or the recognition of the objects as distinct individuals (units); (b) *generalization*, this latter activity involving two sub-processes: (1) *abstraction*, the neglecting of all characteristic qualities save just enough to

limit each object as one; and (2) *grouping*, the gathering together the like objects (units) into a whole or class, the sum.

—McLellan & Dewey: *The Psychology of Number*, p. 32

Although number may be applied to everything in the world, it exists nowhere in the world. The world does not of itself possess number; the world has been invaded by trained minds which have been equipped with number. Objects in the world do not make themselves countable; the child counts the objects which surround him only when he has learned to count. Playing store does not project addition to be beheld and studied; the child keeps accounts only when he has learned to add. Business practices do not of themselves portray percentage; the idea of percentage is brought to business practices to make them meaningful. The complex world does not impress the number system upon the individual; the individual brings the system, as and when he learns it, to the complex world and uses the system as a means of bringing order out of complexity.

—H. G. Wheat: *The Psychology and Teaching of Arithmetic*, pp. iii-iv

Children are not born with a number system as a part of their physical inheritance; they are not endowed at birth with number ideas in any form. The school puts them in contact with a system of number symbols which is one of the most perfect creations of the human mind. In the course of their acquisition of this system, they learn how to think in abstractions with precision. They learn how to use an intellectual device which no single individual, no single generation, could possibly have evolved. In the short span of a few years a child becomes expert in the use of a method of expressing ideas of quantity which cost the race centuries of time and effort to invent and perfect.

—C. H. Judd: *Educational Psychology*, p. 270

Arithmetic is a system of ideas. It is not a collection of objects. It is not a set of signs. It is not a series of physical activities. Arithmetic is a system of ideas. Being ideas, arithmetic exists and grows only in the mind. It does not flourish in the world of things. It does not arise out of sensory impressions. It has nothing to do with the amount of chalk dust forty pupils can raise in a schoolroom in thirty minutes. Arithmetic exists and grows only in the mind. Being a system, arithmetic must be taught as a system. It is not an outgrowth of the individual's everyday experiences. It is not learned according as the interests or the whims of pupils may suggest. It is not anyone's personal discovery or invention. Arithmetic must be taught as a system.

—Harry G. Wheat: *Arithmetic General Education*, p. 80

It is difficult to define a number. All of us use numbers; we have a fairly good idea what their purpose is, but defining them is so difficult that a knowledge of advanced mathematics is necessary in order to express precisely what a number is.

—A. Bakst: *Arithmetic for Adults*, p. 1

Understanding the number system is the essential skeletal framework of a child's mathematics; the problems he solves put sinews on that skeleton and make it move and work for him; but the human aspects of the subject put a living heart into his knowledge and its use.

—*Mathematics as Learned and Used in the Seattle Public Schools*, p. 2

. . . arithmetic, as an abstract science is able to provide its own method for successful conceptual mastery. It is interesting and captivating in itself. This does not mean that arithmetic should be taught to children purely as a science divorced from the concrete, but it does emphasize the fact that it should be taught systematically no matter what method or theory of learning is advocated.

—Louis Ulrich: *Streamlining Arithmetic*, pp. 15–16

In arithmetic, the number system provides the intrinsic relations which constitute the basis for understanding and organizing the multitude of specific skills and abilities which are included in it and controlled by it. This closely knit system of ideas, principles, and processes has a meaning which will not be revealed by dealing with the elements alone. By failing to teach the basic principles of the decimal system, and by requiring the pupil merely to memorize a host of discrete number facts, we deprive him of the only effective means of generalizing his number experiences and of applying his learning intelligently in new situations.

—T. R. McConnell: *Arithmetic in General Education*, p. 270

Beginning with school children in the first grade, if not actually in kindergarten, and continuing through college and the post-graduate seminars, the one subject in the curriculum which needs to be stressed above all others is arithmetic. It is hard to see how modern man can soberly and usefully attack the terribly complicated problems of his world and age without a firm grasp on the principle that four is more than two, that 90 per cent is more than 10 per cent, that fifty-one nations are more than three nations, and that fifty million war casualties are more than ten million casualties.

Sad to say, respect for arithmetic has never stood so low as it does today in this country. People are not content to speak of the three kinds of lies, of which the worst is statistics. They do not stop short at remarking, curtly, that perhaps figures cannot lie but liars can figure. They find that arithmetic is much worse than untrustworthy. They find it a bore. At least this is the caution always addressed to writers for the press and authors of books designed for the general public. Avoid statistics. The public wants its truth presented in broad summations or in vivid anecdote, usually in a combination of both. People simply will not read figures.

And yet the one problem which has come to transcend every other human interest today, or is described as such on every hand, is a problem in arithmetic. What is this atomic age upon which humanity has entered, if not the age of an awesome arithmetic? The atomic bomb is our first visible sample of the overwhelming arithmetic in Einstein's formula for

the equivalence of matter and energy. To get the energy or force locked up in a piece of matter you simply multiply the mass by the square of the speed of light, that is all. You work out an arithmetical sum in which one step consists of multiplying 186,000 miles a second by 186,000 miles a second. The consequences are Hiroshima and Nagasaki and Bikini; otherwise arithmetic is a bore!

—Simeon Strunsky: in "Topics of the Times," *The New York Times*, Sept. 29, 1946

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# HOW SHALL WE TEST?

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The weather is a subject, according to Mark Twain, "about which we talk much and do little." But Mark lived before these days of air travel which impose "weather action" as well as talk. However, action presupposes information.

How, in general, do we get information? As previously indicated, for teaching purposes, the first need is a catalog of the knowledge and understandings expected as an accepted basis for next steps. If we apply that pattern of procedure to "doing something about the weather" we need to know temperatures, air pressures, humidities, air velocities, insolation and wind directions. Every John Doe knows these different weather facts can not be determined by a single testing appliance. To test for temperature, he knows, a thermometer is needed, for air pressure, a barometer is used, for the humidity, a hygrometer; for wind velocity, an anemometer; for insolation, a measure of sunshine and for wind direction, a weather vane is needed. Once these interrelated facts have been learned and tabulated the observer is prepared to propose a program of cooperation with the weather and so, at last, man "can do something about the weather."

How to test in school is not too different from the pattern followed by the "weather man." The present concern, however, is to get an inventory of the tools for getting the facts concerning the student's progress in a given subject, i.e. his change from "what he was" to "what he is."

Just as a different instrument of measurement was needed for each individual sort of weather information so a different sort of procedure has been found necessary to get reliable indications

for each different sort of accomplishment in school courses. To illustrate: it has been found[1] that a test for information is not a valid means of getting evidence of ability to infer. Likewise, the use of test scores on accurate memory of information is not an indication of ability to apply and use that information.[2] Test marks on equations and problems are not found to be valid indicators of abilities related to laboratory work.[3]

An important consideration in the choice of tests to be used is related to their freedom from poor sampling within the area tested. All teachers have been accused, at one time or another, of "picking the questions which the disgruntled student didn't review" in preparation for that examination. This criticism is, basically, a non-agreement of the student with the teacher upon a proper sampling of the topics to be appraised by the test. One plan to avoid this deficiency is to use such a large number of items, well scattered through the entire subject matter area, that a few "blind spots" in the mythical average student's information or understanding will not constitute too great a percent of the test's total requirements. An attempt to use this plan poses a problem in the form of too much time needed by the student in preparing answers to the test's questions. If the essay or complete sentence type of response is required an adequate spread of requirements demands so much writing and time attention from the student that nervous fatigue presently "colors" his answers. Thus those answers do not correctly mirror that student at his best.

Another alternative is to use, what is sometimes called, an indirect sort of testing procedure. This method of testing is the same in principle as the use of a thermometer in testing for temperatures. The mercury in the thermometer does not directly register temperature change but rather the volume change of the mercury. If that volume change is accurately proportional to the temperature change it can be used as an indirect measure of the temperature change. In an analogous manner short-answer or "new-type" tests are often indirect measures of the particular aspect of the subject under appraisal. These tests are increasingly finding their place in our teaching practice. How

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[1] Tyler, R. W., Measuring Ability to Infer. Constructing Achievement Tests. The Ohio State University, Columbus, Ohio, 37 (1914).

[2] Frutchey, Fred P., Evaluating Chemistry Instruction. Educ. Research Bul. The Ohio State University, Columbus, Ohio, 16, 2 (1937).

[3] Hendricks, B. Clifford, Pencil and Paper Tests for Laboratory. Jour. of Chem. Educ. 22, 544 (Nov. 1945).

they are prepared[4] is of interest to teachers as well as how they are to be used.

The short answer type of test has several qualifications that attract examiners. It definitely makes improved sampling possible. A nationally used high school chemistry test has 120 items for a forty minute period and the better students actually complete responses to all those items in that time. Such a test is to be compared with a ten-question essay test that usually consumes a full hour's time. Scoring the short-answer test is less likely to be colored by indispositions of the grader than is the mark of the essay type of test.[5] Scoring short-answer tests is much less time consuming and may often, by use of stencils, be scored by clerical assistants. Probably all readers of this paper know that in our larger high schools and colleges most of the scoring of tests of this sort is done by machine.

That which has been considered in the preceding paragraphs has reference solely to what may be termed "pencil and paper" tests. There are, however, other means of testing less well known to our teaching public. Of especial interest to science teachers are the so called "*performance* tests," Poor validity of equations and problems as a means of judging success in the laboratory part of chemistry has already been cited above.[3] Teachers of chemistry are in very general agreement that one of the aims of laboratory teaching is an improved technique particularly in the manipulation and assembly of apparatus. This might be characterized as "learning the language of test-tubes." There is also general agreement that the surest index of skill in that aspect of the laboratory program is obtained by having the student actually perform the desired assembly or "set-up" under the eyes of the evaluating observer. The few[6,7] reported uses of this plan indicate that it has desirable promise. Its most bothersome defect is that it has not as yet been made to be practicably administrable. Some reasons for its impracticability are: the extremely meticulous planning with stores as well as cooperating laboratory teachers that is necessary in order to get comparable and valid ratings; the difficulty of scheduling

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[4] Frutchey, Fred P., Constructing and Validating Examinations, *Jour. Chem. Educ.*, 15, 40–43 (Jan. 1938).

[5] Frutchey, Fred P., The Essay Examination in Chemistry, *Jour. Chem. Educ.*, 16, 492 (Oct. 1939).

[6] Horton, R. E., Measurable Outcomes of Individual Laboratory Work in High School Chemistry, Bur. Publications, Teachers College, Columbia Univ., New York (1928).

[7] Tyler, R. W., A Test of Skill in Using a Microscope, Constructing Achievement Tests, Ohio State Univ., Columbus, Ohio, 37–41 (1914).

time for each individual member of the class to stage his performance before his observer, and likewise the impossibility of keeping students who report at a later time from profiting by oral "back-reports" to them from students who did their "laboratory skits" earlier in the laboratory performance period. Until these and other elements of administration have been simplified or routinized the use of "performance tests" for laboratory appraisal will be limited. Efforts are being directed toward indirect methods of making such inventories of laboratory accomplishment available.[3]

Another means of estimating improvement or actual accomplishment in laboratory performance is to develop reliable scoring techniques for the "products" of the student's laboratory work. For chemistry these products might be either a prepared chemical or a completed assembly of apparatus for a specified use. A score card, such as that suggested in reference seven above, could be used as a means of rendering marks assigned more objective. For high school use this plan of testing may be impractical because there are very few assemblies involving more than one "operation unit" and the number of students who actually prepare a "scorable" chemical preparation would probably be a very limited proportion of the entire class.

The tentative answer to this paper's title question is, then: First, decide upon those aspects of the subject which are to be appraised. Second, choose, from the various tests available, those or, if possible, that one which is most valid for testing the aspect under scrutiny. In making this choice both the essay and short-answer tests may need to be considered, keeping in mind the merits of both as well as their shortcomings. In what is said above, the writer has assumed that modern high school teachers have been trained to include the *published tests*, in their field of teaching, along with textbooks, manuals, visual aids and laboratory equipment as tools for increasing the efficiency of their service to their students and patrons.

In brief, by the intelligent use of tests the teacher, like the "weatherman" may be better able to do something more in regard to student changes than "talk about them." As the "weather-man," by use of his instruments may more effectively cooperate with the weather as it affects the affairs of men so the teacher by use of his tests may more effectively cooperate with his students to the mutual advantage of all concerned.

# WHAT IS A PHYSICIST?

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A physicist is a fellow who, when he has a problem to solve, reaches for a soldering iron or a differential equation according to the needs of the situation. He may not handle the soldering iron as well as a tinker, and he may fumble with the differential equation worse than a trained mathematician. But he is usually guided by *an idea*, and that is a priceless ingredient in discovering new truths or in bending old truths to new uses. Like Michael Faraday, he is often "more interested in discovering new effects than in augmenting the power of those already discovered." It is this that differentiates him from the engineer, who is commonly regarded as more practical. The engineer has the difficult and important task of reducing new discoveries to practice and of combining practical design with sound economics. The engineer applies physics at a price.

At the time when the engineers were busy applying the discoveries of Oersted, Faraday, and Henry, in the growing electrical industry, the physicists were occupied with electrons, pretty displays of light in evacuated tubes, and the properties of electromagnetic waves—all interesting but rather useless investigations! And forty years later, when the engineers were busy applying these to electronic controls in radio and industry, the physicists had wandered off into another field. They wanted to find out about the core of the atom and they were scratching their heads over a queer new field called "wave mechanics." They had a yen for million-volt generators and hyperfine structure of spectrum lines.

The physicist is endowed with a restless urge to find out what makes Nature tick. He hasn't found out yet and as long as he remains a physicist, he never will be satisfied with what men already know.

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We need governmental efficiency and economy and the reduction of the number of governmental employees, but we must raise the standards for the teachers of the rising generation.

No other single thing is of more importance to our children. It will directly affect all of the other problems of youth and will reflect upon the creative and cultural developments of tomorrow.

HAROLD E. STASSEN

# THE DEMISE OF EUCLID

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That the objectives and content of secondary-school curricula in mathematics frequently change is evident on comparing the textbooks in school algebra, geometry, and trigonometry, decade by decade, back to the 1880's. The reasons for these continual and sometimes drastic changes have often been analyzed and are known to nearly all teachers, so there is no need to rehearse them here. Each change has been a compromise between partisans of the old and proponents of the new. Neither side has ever gained everything it wanted, nor is either ever likely to do so as long as teachers and the general public stay fairly human and retain their sense of humor.

The ingredients for a major controversy are plainly visible today in the discussion touched off by the findings of the military regarding the mathematical qualifications of draftees. Generals, admirals, and technical instructors profess to have been shocked by what they discovered. The competence in even elementary arithmetic which these unrealistic men had expected to find as a matter of course was not as frequent as they had anticipated. Well, nor was the competence of the military, from the generals and admirals down, always as great as the draftees and their parents had confidently expected. Yet nobody has suggested that every male citizen be given a training which would entitle him to wear a brass hat. The remedy for what ailed the draftees may not be more mathematics for everybody, but less for nearly all and much more for those who can assimilate mathematics.

If it be assumed for the purpose of this discussion that any human being of normal intelligence may profit in one way or another from a modicum of mathematical knowledge and skill, what shall be offered as an irreducible minimum? There have been many suggestions. Enough arithmetic to understand the recipes in a cook-book, count change, and check the bank balance (if any) seem to be accepted as desirable. Beyond these

* The Editor asked me for an article that might be of interest to teachers. It seems proper to mention my qualifications, if any, for writing anything primarily for teachers. I have had considerable experience in secondary-school teaching, and years ago earned my life-certificate for such teaching by satisfying the State requirements then prescribed in Education and actual teaching. The opinions expressed here are merely personal, and doubtless contravene those of many others more competent than I in teaching and in mathematics. A safe rule in all divisions of opinion is, examine the evidence and then reach *your own* conclusion, using *your own* head.

Alps of arithmetic lies algebra, and contiguous to algebra lie the smiling plains—or the forbidding deserts, according to taste—of elementary geometry. I shall say very little about the possible teaching of algebra, because I happen to like the subject, and therefore could plausibly be accused of special pleading. As I have never had any great liking for elementary plane geometry, I shall use most of my space to indicate a reason for the retention of at least the barest rudiments of deductive geometry in a general secondary education. If I had had my own way in school, I would have by-passed geometry entirely in favor of more algebra and trigonometry. But I was compelled to take geometry and, being taught by a first-rate teacher, I learned something that has remained, although most of the theorems once painstakingly learned have evaporated.

First, as to algebra, a recent experience may suggest something. Numerous friends, both men and women, have asked me to explain what $mc^2$ means in the formula $E=mc^2$. Nearly all were graduates of universities or colleges. Under liberalized standards of admission and graduation, these enquirers either had escaped algebra or had understood so little of it that the formula was meaningless to them, and it took anywhere from two minutes to an hour for them to understand that $c^2$ is not the same as $2c$ unless $c$ is either zero or two. They had seen the formula—Einstein's equation connecting energy and mass—in articles on atomic energy and the atomic bomb. But they had long since forgotten how to read simple formulas, if indeed they every knew.

From observation of intelligent adults, I believe it is impossible to understand anything about the physical sciences unless, as a very minimum, a knowledge of how to read simple algebraic formulas is presupposed. Much more, of course, is necessary. But that much more, for the average citizen, is not primarily algebra. It is physics, at least up to the stage, in this particular instance of $E=mc^2$, of knowing the distinction between power and energy. This, however, is not a responsibility of teachers of mathematics.

It has been said that some understanding of what the physical sciences do, and how they do it, is likely to be a prerequisite for intelligent citizenship in the coming fifty years. This may be asking too much. If our future presidents, senators, congressmen, cabinet members, generals, and admirals could be assured the current equivalent of what was a high school course in physics

and chemistry fifty years ago, that might be sufficient to deter the really influential miseducators of the adult public from propagating nonsensical and pernicious misinformation. This brings us to the important issue: what, if anything, can be done in the teaching of elementary mathematics to make human beings less gullible than they are? It is not a question of making cynics of high school boys and girls. But if there had to be a choice, some might say it is better to be a cynic than a sucker.

The career of Euclid's *Elements* as a school text in geometry may be used to illustrate the main point. The first four books and the sixth of the *Elements* are about the equivalent of the current full high school course in elementary plane geometry. Euclid never intended his book to be used as a text for schoolboys; it was addressed to mathematicians. Plato demanded geometry as a prerequisite for admission to his Academy because he wished his future philosophers and others—mature young men of high intelligence—to have some skill in the tactics of deductive reasoning; and geometry apparently offered the simplest and clearest examples of such reasoning. In the great depression of the Middle Ages, only the definitions and enunciations of a few propositions in the first book were taught, and that only in universities. Proof had ceased to matter. Abracadabra could profitably have been substituted for this meaningless travesty of geometry. With the revival of learning, the real Euclid again came into European favor, but not immediately as pabulum for adolescent minds. About the middle of the eighteenth century, Euclid's geometry was adopted as a secondary-school text in Great Britain. It retained "that bad eminence" till 1903, when it was finally ousted. France and the United States had abandoned Euclid as a text many years before. For long, Legendre's more comprehensible geometry was the favored text.

"Euclid alone," we are assured by Edna St. Vincent Millay in a classic sonnet, "has looked on beauty bare." That suggests one possible "value" in the study of elementary geometry, the aesthetic. But aesthetics deals with matters on which tastes may differ; and only those who were compelled in their youth to look upon geometry through Euclid's cold and fishy eyes, can have any idea how bare beauty can be made. The experience is something to be remembered with disgust for a lifetime. There must be tens of thousands of Britons and their colonials still living who tried, and failed, in their search for beauty in geome-

try, to cross the Asses' Bridge—the fifth proposition in the first book, which asserts that the angles at the base of an isosceles triangle are equal. But though they failed to cross the Bridge with understanding, they kept on going, memorizing. They had no other choice. In passing, an old rhyme explains the traditional name by saying that not he who fails to pass, but he who safely passes over the Bridge of Asses, is an ass. The geometrical books of Euclid's elements, passing through more editions than any other book except the Bible, probably made more people hate mathematics and loathe geometry than all the less beautiful elementary textbooks of mathematics ever written.

It was not the book that was to blame; it was the teaching. In the endless rote and memorizing of drab propositions, the end for which Plato strove in the mastery of elementary geometry was forgotten or ignored. The teachers were not responsible for their execrable teaching. They were dominated by the examination system, largely competitive, imposed by university professors and others in authority having no experience, except through examinations, with teaching at the school level. Some of the papers these men set rank among the greater classics of academic and educational futility.

In the United States successful opposition to irresponsible meddling by so-called higher educational authorities in things of which they were ignorant came sooner than in other countries. In Great Britain the organized struggle to improve geometrical teaching lasted about thirty-five years. The teachers were progressive, the controlling authorities reactionary. But even in the highest heaven of pure mathematics opinions differed. The two leading English mathematicians of the 1870's carried on their own private war. Sylvester advocated sinking Euclid "deeper than plummet e'er sounded"; Cayley wished to substitute for the modernized versions of Euclid's geometry the unmitigated repulsiveness of a literal translation of the original's repetitive verbosity. In retrospect, it seems unfortunate that Cayley was not sustained. If his proposal had been adopted Euclid's demise might well have been hastened by thirty years, and a whole generation might have learned to use its reasoning faculties instead of its very fallible memory.

The would-be reformers concentrated their efforts in the Association for the Improvement of Geometrical Teaching (the A.I.G.T.). The Association accomplished much in the first thirty years of its activity, including the preparation of im-

proved texts, but nothing decisive. When at last the A.I.G.T. got the incubus of higher inertia off its back, progress was more rapid than some of the members could have wished. In its final struggle, the Association received not only comfort but invaluable aid from an exponent of clear thinking whose opinion on matters logical had to be received with respect even by examiners and professors of mathematics. When asked to help the teachers, Bertrand Russell in 1902 published his opinion of Euclid as a textbook for schools. As what he wrote is relevant for some school geometries in use today, I transcribe it.

"It has been customary when Euclid, considered as a textbook, is attacked for his verbosity or his obscurity or his pedantry, to defend him on the ground that his logical excellence is transcendent, and affords an invaluable training to the youthful powers of reasoning. This claim, however, vanishes on a close inspection. His definitions do not always define, his axioms are not always indemonstrable, his demonstrations require many axioms of which he is quite unconscious. A valid proof retains its demonstrative force when no figure is drawn, but very many of Euclid's earlier proofs fail before this test."

Russell then backed up his assertions with a detailed analysis of Euclid's earlier proofs to substantiate his criticisms. One example concerns Euclid's very first proposition. As this brings out a capital distinction between two conceptions of "geometry," one of geometry as a partly empirical science, the other of geometry as a purely deductive science, the proposition (a problem) and Euclid's construction may be stated. The problem is, "To describe an equilateral triangle on a given finite straight line." The construction: "Let $AB$ be the given straight line. From the center $A$, with $AB$ as radius, describe the circle $BCD$; from the center $B$, with radius $BA$, describe the circle $ACE$. From the point $C$, at which the circles intersect, draw the lines $CA$, $CB$ to the points $A$, $B$. Then $ABC$ is the required triangle." Russell's comment: "The first proposition assumes that the circles used in the construction intersect—an assumption not noticed by Euclid." A quibble? A triviality? Unfortunately for Euclid's system of geometry, it is impossible to prove from his assumptions (axioms, postulates) that the circles intersect. Nor is it possible to do the like using only the assumptions stated in any textbook of school geometry now in use that I have seen —and I have looked at a great many. There is nothing new in any of this; it has been known for several decades to all competent mathematicians. That Euclid's oversight is not a trivial-

ity is sustained by the fact that systems of geometry, useful in some parts of science, have been constructed in which the circles do not intersect. Having pointed out equally disastrous flaws in several further proportions, Russell summed up as follows:

"Many more general criticisms might be passed on Euclid's methods, and on his conception of Geometry; but the above definite fallacies seem sufficient to show that the value of his work as a masterpiece of logic has been very grossly exaggerated."

That was in 1902. Euclid as a school text for the teaching of elementary geometry in Great Britain was abandoned the following year. The commotion stirred up in the press (and even in some pulpits) by this unseemly jettisoning of a hallowed tradition was almost as great as if Queen Victoria, concluding her record-breaking reign with one supreme gesture of profane disgust, had heaved the roast beef and Yorkshire pudding of old England to the sharks. Irate gentlemen, brick-red and with bristling white mustaches, stewing in their Service Clubs, scrawled steaming letters of protest to the newspapers. They had been weaned on Euclid, they were proud to recall. They distinctly remembered writing out the demonstrations of three propositions in the competitive examination for admission to one or the other of those famous (and antiquated) military academies, Sandhurst and Woolwich. Having beaten the examination, they had marched on to their duty of cracking the enemies of the Crown over the head, wherever they might be found. It followed, therefore, according to the close reasoning these empire builders had imbibed from Euclid, that a thorough drill in Euclid was both necessary and sufficient for the continuance of the British Empire. They may have been right; but at the time it appeared that whatever Euclid had taught them, it was not the ability to distinguish between their emotions and their reason. American teachers whose memories reach back thirty years or more can recall equally emotional defenses, on this side of the Atlantic, of cherished beliefs, or vested interests, in this, that, or the other sanctity of an established mathematical curriculum.

Euclid's mishap with the equilateral triangle suggests several things of interest for present-day teaching of geometry. What can be proved depends upon what is assumed. The assumptions are called axioms or postulates. If anyone wishes to prove that the two circles in Euclid's construction do intersect, several

postulates must be added to those usually stated in school geometry. Likewise for many other theorems and constructions in the usual course. Such logically sound developments of elementary geometry, based on Hilbert's postulates (1899), were prepared as school texts about forty years ago. (I forget the authors' names, but they may have been G. B. Halsted and W. B. Smith.) Anyone with a grain of common sense could have predicted the total failure of this attempt to raise school geometry to the level of the graduate school. It was an asinine thing to do. Worse, it was shoving scholarly pedantry to a limit far beyond poor old Euclid's farthest.

If we cannot be logically rigorous in our teaching of a supposedly logically rigorous subject, we may be able to compromise for a little honesty and some plain sense. If we are attempting, among other things, to elicit and develop "the youthful powers of reasoning," we might first explain to our pupils what we propose to do, and why. If they understand that in proofs only the stated postulates and what has been deduced from them are to be permitted, they will try to play the game fairly, and not slip in surreptitious assumptions to make proofs easier. Once warned and then repeatedly reminded of what the rules of the game are, they will quickly learn to detect hidden assumptions. When some alert pupil notices, say, that the construction used in proving that an exterior angle of a triangle is greater than either of the interior angles opposite to it, demands an assumption (most probably) not stated among the postulates of the text, the teacher may do one of several things. If he does not know his business, he will bluff it out one way or another and thereby forfeit the attention of at least one pupil. If he cannot remedy the defect, he may ask the class to accept the assumption, add it to the list in the book as a postulate, and go ahead. Other ways of proceeding will doubtless suggest themselves to any experienced teacher.

To bring out any dangers there may be in relying entirely on the senses to the exclusion of the reason, the old Greek device of instruction by occasional fallacies may be useful. The inexplicit assumption in the usual proof for the equilateral triangle has been detected by properly alerted boys and girls of fourteen; the following classic example has puzzled many pupils much older. It should be presented before the study of circles is begun. To prove that all triangles are equilateral, draw (not too carefully) the scalene triangle *ABC* on the board, and let the

perpendicular bisector of the side $BC$ intersect the bisector of the angle $A$ at the point $O$ inside the triangle. Draw $OA$, $OB$, $OC$. Then everything goes smoothly, and it is proved that $AB$, $BC$, $CA$ are equal. This disconcerting discovery may suggest that before beginning demonstrative geometry, the pupils could profit by a few simple exercises in geometrical drawing to familiarize themselves with the geometrical objects they must learn to reason about. This brings us back to the equilateral triangle.

Any draftsman knows that an equilateral triangle can be constructed by Euclid's method, although he may not know how to give a strict proof for his construction. For his purposes proof is irrelevant. He is dealing with experience on about the same level as that on which a student of physics determining the specific gravity of lead operates. His methods work and, in the realm of sensory experience, are accurate within the limits of ascertainable error. The draftsman is using his geometry largely as an empirical science applicable to sensory experience. The more difficult constructions he uses have been certified as sound—within the prescribed limits—by men working on another level. The like holds for vast tracts of pure and applied science and technology. It also holds for a majority of pure mathematicians. I have known exactly one mathematician who never accepted a single statement by another mathematician, no matter how eminent, without first working out his own proof. Life for most of us is too short for such zeal.

But because many can get along in their trades or their professions without ever proving anything, it does not follow that nobody can get anything of value out of understanding once in his life what proof means in the mathematical sense. It means strict deduction from explicitly stated assumptions. Nothing that is not stated in the assumptions, or has not been deduced from them, is to be used. Elementary plane geometry, with its convincing diagrams and plausible constructions, is an ideal subject for teaching adolescents to use their brains as well as their hands and their eyes. If they can be taught to realize that even in this simplest kind of reasoning, where they think they can see everything, there is no proof without assumptions, they may be conditioned to ferreting out the assumptions in other, more confused, types of reasoning. They must be told what to look for—the assumptions, conscious or other. If they find the assumptions reasonable, or workable, they may assent to the con-

clusions. If they find themselves accepting repugnant or suspiciously agreeable conclusions, they may be moved to seek the underlying assumptions.

It may be utopian to hope that any considerable fraction of a school generation can be made critical of orators, slogan-mongers, and others who grow fat and prosperous on the spoken or written word. But it might be worth a trial. If the trial is to be made, a handful—say a dozen—of extremely simple propositions, carefully analyzed by the pupils after they understand what the propositions mean, should suffice to prepare them for similar scrutiny of simple assertions in subjects other than geometry. The results, of course, might be disastrous. Wilbur or Ethel, for example, might begin to doubt that the word of Father was invariably the word of God. A little later in their wayward careers, they might begin prying apart the planks of Senator Snort's platform and, having demolished it, vote for his opponent, Senator Snodgrass, who had sense enough not to stand on a collapsible rostrum of old boards. But this hope surely is utopian.

If any teacher wishes to give the foregoing suggestion a trial, a carelessly prepared text has its advantages. A text written with scrupulous honesty and care to point out exactly what has been proved and what must be taken for granted until the pupil is more mature, offers too few opportunities for developing critical insight to be of much use in teaching people to think for themselves. Whether the book is good or bad by any standard, the success of the teaching depends solely on the teacher.

I have not forgotten the cook-book and the bank balance. A person who has learned to think critically is more likely to have either or both at the age of forty, than is one who has memorized any number of theorems in geometry without understanding.

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## FELLOWSHIPS AT CASE SCHOOL OF APPLIED SCIENCE

Case School of Applied Science will offer fifty fellowships to high school teachers of physics for a six-week program of study during the summer of 1947, according to an announcement by Dr. William E. Wickenden, president of the Cleveland (Ohio) engineering college.

Recognizing the fact that industrial research and progress stem largely from a knowledge of physics, The General Electric Company has provided these fellowships for high school and preparatory school teachers of physics. The program is designed to acquaint teachers with recent scientific developments.

## CHEMISTRY NOW HAS A NEW EDITOR

Mr. Kenneth E. Anderson, acting principal of the University High School at Minneapolis, is our new editor for chemistry replacing Dr. E. G. Marshall of LaSalle. Since the close of the war Dr. Marshall's teaching duties are so heavy that he has little time for other activities.

Mr. Anderson received the B.S. degree from the University of Minnesota in 1932 and the Master's degree two years later. He is now continuing his work for the Doctor's degree, studying the abilities of the secondary school pupils of Minnesota particularly in biology and chemistry.

Thirteen years ago Mr. Anderson began work as a teacher and has advanced rapidly. In 1944 he became science instructor at the University High, a year later he was advanced to the head of the science department and assistant director of the high school, and during the present year he is acting principal of the high school and instructor in elementary science methods. Now as editor for chemistry for SCHOOL SCIENCE AND MATHEMATICS he will be pleased to hear from anyone who has new ideas for chemistry teachers.

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### EXAMINATION ANNOUNCED FOR MATHEMATICIAN

An examination has been announced by the Civil Service Commission to fill high-grade Mathematician positions located in Washington, D. C., and vicinity. The salaries range from $7,102 to $9,975 a year.

These positions require a thorough knowledge of mathematics and related fields, and a proven capacity for performing original and independent scientific research or other difficult professional work involving the field of mathematics. Because of the importance of securing applicants with the required qualifications for this examination, selective publicity is being used in an effort to reach the best possible candidates.

Applications will be accepted until further notice. Interested persons may obtain information and application forms from most first- and second-class post offices, Civil Service regional offices, or from the U. S. Civil Service Commission, Washington 25, D. C.

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### OPTICAL FIRM GIVES TELESCOPE TO WARNER & SWASEY OBSERVATORY

Gift of a three-inch Transit telescope to the Warner & Swasey Observatory at Cleveland, Ohio, has been announced by Bausch & Lomb Optical Company.

Formerly housed in the optical firm's observatory at Rochester the telescope and recording micrometer were used to observe transit of stars in determining sidereal time. In its new location, the instrument will be used principally for instruction purposes.

# IS ELEMENTARY SCIENCE IMPORTANT?

ANNA E. BURGESS

*Supervisor of Elementary Science, Cleveland, Ohio*

To those who are teaching elementary science, the answer to this question is obvious—an unqualified, "Yes, of course." But there are many places where boys and girls in the elementary schools are being denied the values to be derived from science experiences. The most commonly heard objection is the lack of time. This whole problem of possible organizations to include elementary science could be discussed at length, but it falls into a secondary place when one realizes that the values accruing to pupils from learning situations in science more than compensate for the time required. Let us look at some of these values.

Elementary science, more than any other subject in the curriculum, is a source of real life experiences for children. In reading, social studies, arithmetic, and other traditional subjects, the experiences are more often of the dramatized, vicarious type. They do not deal with the actual materials from the everyday life of the child. This reality means much in the child's educational progress. Surrounded by materials that he can handle and work with, or watch and care for, he talks spontaneously about what he is doing and seeing.

Last year I saw an assembly program given by a group of over-age, mentally slow boys and girls working on an academic level corresponding approximately to fifth grade. The reading levels of many of these children were lower than those of the average fifth grade. Their program consisted of demonstrations of experiments that they had performed to learn about air. With no memorized speeches to hamper their thinking and their oral expression, they talked freely as they performed their experiments telling the audience what materials they were using, explaining each step as they went along, and stating what the experiment seemed to prove. The manipulation of materials as they worked seemed to remove all evidence of stage fright and formality. Not only in assembly programs, but in many classroom situations as well, I have seen this promotion of free, natural speech through the suggestion of the teacher that the pupil talk to the class as he shows what he is doing. Expression grows with opportunity. Even the most phlegmatic child will talk if he has something interesting to tell or to show to the other boys and girls.

In the lower primary classes, boys and girls will talk spontaneously when they are watching some live animal. The vocabulary grows. The sentences come naturally. Frequently, the group with the teacher will compose a chart to record what Jack's puppy did, or what they have learned about the goldfish in their aquarium. Here they see their own sentences in manuscript form and they delight in sharing them with any visitor to their room. The teacher of primary reading finds these real experiences the richest source of materials for the early language and reading charts. Because the child can visualize the experiences, every word has a definite concept behind it. Science does more to develop meanings for beginning reading than any other phase of primary work, because the experiences are real. The children live the experiences, tell them, record them, and read them.

All through the grades, science motivates reading. Elementary science is not primarily a book subject, because the facts and principles are acquired through experiences, but following the experiences there are so many reasons for reading! What other facts can you find out? Does the information in books agree with what you have observed? Are there more experiments along this line? Will you compare what several books say about this to find out if all the authors agree? The alert teacher finds many reasons for referring children to books.

Literature or stories in the school readers often furnish motivations for science reading. One class was reading *Rabbit Hill*, by Robert Lawson (Viking). They began to ask, "Do the animals really do these things?" The teacher, always alert to possibilities for the interrelation of subject matter, suggested that they find out. The boys and girls not only did an amazing amount of research but their discussions were so interesting that they were asked to present a final discussion over the school radio system. They discovered that they had missed much of the humor of *Rabbit Hill* because they had not known the factual side of the story.

Teachers who are concerned about the advancement of their pupils in reading, writing, and speaking, are finding that science, far from robbing them of time, contributes greatly to the pupils' interest in these subjects. They read more, and write and speak better, because they are intensely interested in finding and imparting information.

Emerson has said that thinking is the hardest thing we do, but the most necessary. It is doubtful if the *ability* to think can

be developed, but surely ***patterns*** of scientific thinking can be built up through use in many, many situations. Children can learn to find valid answers to many of their own questions in this way, until it becomes a habit after many experiences, to utilize a certain procedure in solving new problems.

A question arises, or the teacher brings up a question for consideration, and a procedure somewhat as follows is set up:

1. What do you already know that will help you to answer this?
2. Do you have an idea of the probable answer?
3. How can you find what you need to know to answer the question truly? Should you watch what happens and keep records over a period of time or perform some experiments to test your idea?
4. How can you verify what your observations seem to show? Should you consult books? Talk with someone who is an authority on the subject? Compare your results with those of others?
5. What is the answer to your question? State it in your own words, then find a statement in the science book.

This is, of course, a simplification of the traditional wording of the scientific method, but the procedure is the same. Simple phases of it can be begun even in the kindergarten and the procedure developed until the older children follow it as a matter of course. Here is an example of a kindergarten phase of scientific procedure: When some child concludes that all guinea pigs are black and white, because the pet in their room is of that color, the teacher may ask, "How many guinea pigs have you seen? Shall we look at some other guinea pigs to find out if all of them are black and white?" Then a trip to a pet shop, or a series of pictures, can be used as a means of gathering data pointing toward a true statement.

Elementary science serves to orient children in their world. When they enter school at the age of five they have had very limited experiences. Their powers of observation have usually been confined to themselves, their family, and their home. The outside world of natural and physical phenomena holds many sources of fear because they lack the knowledge to understand these phenomena. Through science experiences they overcome their fear of harmless animals, they learn how to care for and handle their pets properly, and are taught necessary cautions to avoid developing difficulties and new fears. Such superstitions as that all snakes are poisonous and that toads cause warts are dissolved through experience and research. A Reptile Club in grades four, five, and six in one school has not only dispelled fears but has developed permanent interests and appreciations of the reptiles of the world. Each member has a reptile for a

pet, either at home or in the science room. At the monthly meetings of the club, different members give reports about some kind of reptile. At a recent meeting, four very "scholarly" reports were given about the four poisonous snakes of the United States.

Any list of leisure time hobbies consists of a large number of activities motivated by natural or physical science. The teacher of science has a definite responsibility to help children to get started on some hobby that will be valuable to them outside of school. Not every child will want to continue an interest in science but his life will be enriched and his leisure time well spent during the period that the interest holds. And who knows but that a new hobby may be the motivating factor in choosing a vocation for life?

Elementary science, then, contributes much to the academic progress of our pupils, to their ability to think scientifically, and to their enjoyment of living. But in addition to these contributions, elementary science begins the development of the appreciation and understanding which every citizen must have to succeed in the world today. Science meets us on every hand. If we meet it with ignorance, fear, and superstitition, science will conquer us. If, on the other hand, we possess the weapons of understanding and appreciation of what science can do and of what it cannot do—we shall be able to control its contributions and to direct them into channels of benefit to the human race. Waiting until the pupil reaches high school to introduce him to his world is too late. Every boy and girl needs science *now*!

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## HUBBARD CHART OF THE ATOMS

A new 1947 edition of the Hubbard Chart of the Atoms is now available. The outstanding addition is the newly discovered elements resulting from atomic bomb research. 1947 Atomic Weights are included and all constants have been revised to correlate all recent research as applied to all of the 33 different characteristics of the atom making an up-to-date tool for the student and research chemist and atomic physicist. The manual accompanying it has new tables and graphs of correlation of atomic structure with physical and chemical properties. W. M. Welch Manufacturing Company, 1515 Sedgwick Street, Chicago, Illinois,

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I urge that a thousand newspapers across the country print on their front pages their local teachers' salaries and the earnings of local bartenders and of local elevator operators.

HAROLD E. STASSEN

# TEACHING ALGEBRA

## OBSERVATIONS BY A "STUDENT TEACHER"

RAYMOND S. BRICKLEY
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Perhaps we should change the word "algebra" to something else, something which will not put such fear into the minds of children when they hear the word mentioned. For some reason or other pupils about to enter a course of study in algebra are imbued with this fear and such children are almost licked before they start. They have learned from older brothers or sisters or friends that algebra is very difficult to master and they take it for granted that they too will find it hard. These older brothers or sisters have heard this from those before them and therefore they were impressed with the same idea. And so it has carried down through the years until now we are faced with the problem of just how to dispel this fear. This is one of the main questions that I would like to consider in writing about the teaching of algebra.

It is true of course that children who have spent from six to eight years studying arithmetic will have some difficulty beginning to think and reason in algebraic terms. They are faced with a new and different approach to the study of quantitative relationships, having new symbolism, new concepts, a new language, and a higher degree of generalization.

Many times, though, the teacher fails to realize this and, through long familiarity with these concepts, permits them to become sheer habitual reactions. He fails to see why certain difficulties exist for beginning students and soon loses patience with those who do not grasp ideas quite so quickly. Hence a good teacher must recognize these difficulties and formulate a means of helping the students avoid or overcome them. If he fails to do this, then the course becomes merely a group of manipulations and rules which have no meaning whatsoever for the pupils. I believe that this is one of the main reasons why algebra has come to be regarded as it is by beginning students today.

During my short period of student teaching, I have noticed this fear, as I call it, to exist among several of the children. I have done everything possible to give meaning to each and every type of problem that we have encountered so far, but still I find some of the pupils trying to make it more difficult than it actually is simply because the idea that algebra is a hard course

is deeply embedded in their minds and they want to make it so. For this reason one of the first things that I did was to try to explain to them that there is no reason for them to consider algebra difficult. I told them that it is, of course, a big change from the mathematics that they were accustomed to, but that now the main things required are good, logical thinking; good, clear habits of reading; the ability to reason; and the ability to concentrate on a problem until they know just what they are doing and why. Even now when I discover that a pupil is trying to make an easy problem difficult, I take time out to emphasize these things so that perhaps I can restore their confidence in themselves.

I believe that the most important things leading to teaching a successful course in algebra are the proper introduction and good methods of teaching. It is common practice that the study of algebra begins in earnest in the ninth grade, but exposure to some of the fundamental concepts should take place in the seventh and eighth grades. The question then arises as to just how far we should go at this level and how much the child can absorb. Let us consider this question momentarily.

The algebraic work to be included in the seventh and eighth grades should not be too extensive and formal. If possible, try not to refer to this work as algebra, but tie it in with the arithmetic so that the children will not be aware of the transition that is taking place. The main objective should be to give the students an introduction to the meaning of certain useful and basic algebraic concepts such as literal numbers, formulas, and the symbolic language of algebra. At this stage, the teacher should not attempt to emphasize too large a degree of technical skill but rather to set up a sound transitional basis for later work by providing mathematical experiences which are interesting to the student and have some definite relation to problems of everyday life.

To say definitely just what algebra should be taught in the lower grades is rather difficult but I believe that it is best stated in the *Fifteenth Yearbook of the National Council of Teachers of Mathematics:* "The algebra that has been successfully introduced into grades seven and eight up to the present time has been limited largely to the understanding of the basic concepts, to the evaluation of formulas, and the solution of very simple equations. It seems possible and also desirable to include other algebraic material; but, if it is to prove effective, the work

should be carefully planned and be so organized as to be significant in itself as well as designed to furnish a good foundation for later algebraic study." A good criterion for determining the appropriateness of algebraic material for the seventh and eighth grades has been suggested by H. C. Barber in *Teaching Junior High School Mathematics*: "Any algebra which may be introduced into these grades should be subjected to three tests. Is it interesting? Is it useful? Is it thought-provoking? And to these there may be added a fourth: Does it prepare for the new algebra of grade nine?"

It is in the ninth grade that the serious study of the subject begins for most students, and it is with this grade that it ends with many of them. The student's interest is either aroused and nourished or allowed to die. If he gains the necessary skills, he can go further; but if he fails, his way is blocked not only in mathematics but also in many related fields. Thus the ninth grade is the most critical grade so far as algebra is concerned.

But maintaining interest is very difficult. There are many things that we must teach in algebra which are quite hard to justify in the eyes of the students. In order to maintain interest we must be able to show some reason for teaching each particular lesson. Every teacher has been faced with the questions from students in the class, "Just what good will this do us?" or "How will we ever be able to use this?" In a recent lesson while I was teaching algebraic long division, the first question arose. For a moment I was not sure what to say. I knew that if I couldn't justify its use, I might as well quit right there for their interest would be lost. So I went on to tell them that just as they had to learn addition, subtraction, multiplication, and division in arithmetic in order to solve many common problems, they would also have to learn these fundamentals in algebra so that they would be able to solve problems that they would meet not only in higher mathematics (for those who intend to continue its study) but also in the sciences that they would study in the next few years. I am still not sure that this was the proper answer but it seemed to satisfy the class and thus their interest continued. The fact remains though, that we must be able to justify all of our teaching or it is practically worthless.

As I have said before however, the introduction must be a proper one. Texts designed for teaching algebra in the ninth grade begin in several ways; namely, solution of equations, directed numbers, the fundamental operations, graphs, or formu-

las. I believe that either of the last two are good topics to start with because there are many problems here that can deal directly with everyday life and it is not hard for the students to see their practical use. When they are introduced to algebra with something that will teach them how to measure areas, distances, and volumes: how to compute interest; or how to read the graphs they see in the daily newspapers and many magazines, they will be able to see a practical reason for studying this subject. This is the thing that children want and they will be willing to put forth more effort to achieve their goal.

If we introduce the study of algebra with the formula, we can begin before we actually admit that we have reached the science itself. This, of course, requires skillful handling by the teacher himself. It is easy to introduce a few simple formulas without actually calling them by this name. There is a group of formulas that easily justify the teaching of algebra to everyone. Under the "geometry of size" the skillful teacher can develop certain mathematical rules and then teach the pupils how to translate them into the shorthand of simple formulas. When we have recognized the value of the formula, the next requirement is to know how to derive one formula from another. The pupils will need these skills in almost any field. Such a study of even some of the simpler formulas will put the pupil into the way of functional thinking, which is one of the things for which we are striving in teaching this course.

Suppose, though, that we choose to introduce our course with the study of graphs. It is easy to show children that this is something that they actually need to understand. They will meet with it everywhere in ordinary reading, usually as a bar graph or as a curve. What is needed here is chiefly the reading and interpretation of both statistical and mathematical graphs. The graph is seen in the advertising columns of our newspapers, in magazine articles on all sorts of economic questions, in industrial manuals, and even in summaries of athletic records and scores of games. However, the work connected with these types of graphs is mostly drawing and the mathematics is merely arithmetic. But it ceases to be quite so simple as soon as we consider the graph of a formula. If we teach the pupils that the graph is a formula represented by a picture, we have a good method of introducing the formula along with the graph. We can pick out many formulas that are interesting to children and show how by graphing them we can read many interesting rela-

tionships directly from the graph. So the fact that the graph holds interest and shows its practicality is a good reason for using it as an introduction to algebra.

Another helpful point which I have recently run onto is not confined to algebra alone. It relates to high school mathematics in general. That is the subject of mathematical guidance. I believe that a really efficient guidance program is one of the most important parts of our high school today. If a school has such a program in operation, the mathematics teacher who is really interested in the welfare of his students will do well to take advantage of this fact. It is assumed that the counsellor has accumulated data concerning each child and attempts to place the child mathematically. The counsellor and pupil together determine a program of study. This is the crucial point. If the child is average or better and the academic course is preferred, algebra is his solution. The same type of student, but undecided as to which course to pursue, should have the opportunity for exploration in a good general mathematics course. It is at this point that the teacher takes over in this program of mathematical guidance.

Since mass instruction has its serious drawback in not being able to meet the needs of each pupil, the first item in classroom guidance is homogeneous grouping of abilities. This grouping should be according to superior, average, and slow groups. This gives us the opportunity to give more to the superior group while at the same time the pupil in the slow group can at least develop a feeling of success in being able to do the work.

The guidance-minded instructor teaches the building of concepts and principles through understanding and learning in a variety of concrete situations. Drill becomes meaningful practice and skills are learned with attention. Besides working at the proper level of ability and building concepts and principles, one must also consider whether or not his interests are being reached. If a vocation has been determined, the teacher and pupil both should know its mathematical requirements and an occasional problem from that field should be worked out. One of the most outstanding ways to keep these mathematical interests is to have in connection with the classroom a mathematics "lab." Here should be located a library with more than mathematical texts—histories of mathematics, popular editions of mathematics, biographies of mathematicians, books on mathematical recreation, vocational guides, etc. There should also be glass

cases for exhibits and geometric forms. Another important thing to have is a group of every kind of mathematical instrument which when used bring mathematics to life. This is the classroom where it is fun to work and which children reluctantly leave.

In teaching algebra it is quite often difficult to keep the attention of the whole class. I have tried several ways of trying to overcome this but there is one method that I have found particularly successful. I will often start off the class by having each student take a clean sheet of paper, the one on which they will do their assignment for the following day, and then as any one of the class or I am solving a problem or developing a method on the board, I will have the remainder of the class follow by doing their own thinking and writing out the solution on this paper. This then will be turned in and scored with their homework the next day. There may be several things to say against this system in that there is a tendency to copy whatever is put on the board and thus do little thinking. However, they are giving their attention to the classwork and they must absorb something—at least more than they would if their attention is concentrated elsewhere. The fact that this work will be scored along with their assignment, offers a good method of motivation.

Another point which I would like to give some consideration is the daily assignment. Too often in algebra a specific type of problem is covered in class each day and the assignment is made so that it includes this type alone. It follows then that as soon as this one assignment is completed that type problem is forgotten and we move on to another. However, I believe that if fewer problems of one particular type are given and several different types are included in an assignment, this will offer a continual review so that the period of retention will be longer. This is another system that I have also tried and it has proven to be very successful.

In writing this I have tried to cover some important points concerning algebra but I realize that I have touched on only a few and have several times drifted off into mathematics in general. However, in conclusion, I would like to consider the mathematics teacher in general and some qualities which he should strive to maintain. I believe that this can best be done by referring to a paragraph from a recent article in *The Mathematics Teacher*.

"The instructor is as much a student of human nature as he is of his subject. He is sympathetic with the learner but not

overly so. He listens to difficulties and aids the pupil indirectly to make decisions to help himself. He is confidential with personal information. Youth loves activity and learns by doing, and he is a wise teacher who capitalizes on this characteristic. He sees details and sequences which make up the entirety and teaches to bring out the whole pattern. He gives the children the pleasure of discovering relationships and teaches to make this possible. He believes in previewing a new unit and his reviews are new views. He correlates all branches of mathematics at every opportunity and with other subjects when possible. He insists on neatness and organization of work in notebooks. He teaches his pupils through mathematics to estimate, generalize, evaluate, and to note similarities between the old and the new. Moreover, he is a teacher who understands youth and they understand and have faith in him. He is inspiring and he has lived. He is alive and so are his pupils."


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## AMERICAN SCIENTIFIC JOURNALS IN FOREIGN LANDS

The U.S.S.R. has more subscribers than any other foreign country to American technical journals in the field of physics, according to an analysis of subscription lists of the eight journals published by the American Institute of Physics.

Foreign subscriptions for the Institute's journals which report new research in nuclear energy, optics, acoustics and similar fields, are at an all-time high, Dr. Henry A. Barton, Director of the Institute, reported in an article on international relations in physics in The Review of Scientific Instruments. They represent 23 percent of all subscriptions, and 59 countries appear on the subscription lists. England ranks a close second to Russia in number of subscribers.

"There is a tradition among physicists all over the world that any individual is welcome at any time in any other individual's laboratory to talk freely about anything that either is doing," said Dr. Barton. "This tradition persists in spite of setbacks during the war. The restoration of this tradition, in fact as well as in theory, is the aim of the Institute, and we do not think that anything else we might do would go so far to re-establish satisfactory international relations in science.

# ELEMENTARY SCIENCE IN AN INTEGRATED PROGRAM

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The introduction of the intermediate grades, seventh and eighth, into the Milwaukee Pulaski High School presented a problem as to what type of a curriculum to offer these young people. A traditional junior high school program, with its rather distinct subject divisions, may have been the easiest to administrate; however, the contributing elementary school has a modified program of subject integration. An abrupt change into a curriculum of disunified courses would have made the transition from the elementary school to the junior high school needlessly difficult. It was decided, therefore, to present a curriculum of unifying courses with all subject matter integrated into a large area of exploration.

The introduction of science into the integrated program was planned to provide a natural relationship between it and other subject matter, rather than to superimpose an unrelated science program for the sake of inclusion.

At the seventh grade level the areas of exploration were the Colonial and Revolutionary War Periods, roughly from 1700–1800. Science in the unified program was to illustrate that science and invention are not immediate developments, but rather evolutionary processes in which men throughout the ages have contributed to the scientific advancement of mankind. A theme as broad as this permitted a close correlation of science with the large area of exploration and at the same time gave the students a maximum of latitude in its development.

As an introduction to this basic theme, some of the scientific progress of the present was compared with the state of scientific progress during the Colonial Period. From this simple introduction followed a natural unfoldment of the project. One group of students elected to compile a list of inventions we have today that early Americans did not have. This list took on staggering proportions. Another group decided it would be interesting to compare the environment of the twentieth century with the environment of boys and girls of the Early American Period. They did this by writing a diary account of a day spent by a child of the Colonial Period and a similar account of a day's experiences of a child of today. The comparison of the diaries

of children of the two widely separated periods in history gave them an acute awareness of the scientific progress that had taken place.

Another development was that the students had become interested in some particular phase of science or invention of the Colonial Era. The following list represents their selections for personal research:

Science of the Colonial and Revolutionary War Periods

A. Natural Resources
   1. Coal
   2. Metal
   3. Lumber
   4. Oil
   5. Agriculture

B. Manufacturing
   1. Cloth
   2. Shoes
   3. Tools
   4. Farm implements
   5. Guns
   6. Milling of flour

C. Transportation
   1. Horse-drawn coaches
   2. Sailing vessels
   3. Steam boats
   4. Steam locomotives
   5. Submarines
   6. Lighter than air craft
   7. Roads

D. Power
   1. Steam engine
   2. Electricity—Benjamin Franklin

E. Public Health
   1. Medicine
   2. Surgery
   3. Food preservation

F. Communication
   1. Printing
   2. Couriers
   3. Telegraph

G. Weather Prediction
   1. Almanac

The general procedure in the development of the individual topics followed along these lines:

1. Student demonstrations were encouraged. The materials and facilities for performing the experiments were provided.

2. A library of science books was made available in the classroom and it was suggested that students could augment their findings by consulting other books in the school library and at the public library.

3. If they had talent in model building they could build model replicas of the inventions they were studying.

4. A day was set aside for a field excursion to the Milwaukee Public Museum. Here, under teacher guidance, they could continue their investigations.

5. Pictorial information depicting early American life became part of a class bulletin board display.

6. Student cooperation was encouraged through mutual aid. When a person discovered information that might be helpful to another, the source of the information was referred to the student concerned.

7. Films depicting the Colonial and Revolutionary War Periods were viewed that the students might have a better understanding of the background of that era.

After reasonable progress had been made, student-teacher conferences were held. Some of the pupils had difficulty in finding information, some were not able to organize their material, some were seeking additional experiments for demonstration, some had information that they did not understand, and others needed encouragement.

Student-teacher conferences brought about a desirable relationship between the instructor and the pupil. The problems had now assumed a sense of real importance and together, teacher and student, would seek a solution. The conferences also revealed that the selections might have been influenced by the fact that the student's parent was engaged in a profession or trade closely allied to his chosen topic. Whenever this was true, it was suggested that the student consult his parent, and perhaps they could work out the problem together. Later illustrations will show how well this tied up the school with the home.

When the teacher and student were satisfied that the topics had been satisfactorily developed, they were then presented to the class. The degree of topic development varied with the ability of the pupil. In cases where the student lacked ability there were definite limitations, but the interest and desire were present and the student was encouraged to progress to the best of his ability. Conversely, the gifted pupil was unrestrained in his development, and the goal set for the exceptional student was a

challenge to him. A plan of this nature recognized individual differences in children and allowed each child to develop to the maximum of his ability.

Because previous school experiences had trained these young people in socialized recitation, they were very responsive to a classroom situation. They came prepared for their topics with books, notes, charts, drawings, and demonstrations. They invited comments and questions and an interesting discussion of give and take followed each topic. Statements not well documented were questioned and experiments were repeated when the proof did not seem conclusive.

How the home and the school worked together is illustrated in the following topics.

One of the students selected medicine of the Colonial Period because her father is a physician. Together they consulted historical medical books and medical journals and a few of the interesting observations they came up with were:

"Barbers were also surgeons."

"The barber surgeons had red and white striped poles. The red stood for the blood of the people they bled, and the white for the bandages they used. The pole itself represented the person they treated."

"For shortness of breath pills were compounded of viper flesh and lungs of foxes."

"For fever the doctors applied salt herring to the feet."

"No license, state board examination, internship, or a certain amount of schooling was required of a doctor."

"A colonial doctor's pharmacopoeia contained these items: St. John's Wart, Clown's All Heal, Four Great Cold Seeds, Saffron and Parsley, Elder and Snakeroot, Iron and Antimony."

The students were very much amused by the medical practices of the early Americans, but it was pointed out that the attempted cures, which amuse even the children of today, were accepted by the best scientific minds of that era.

In her demonstration, the student displayed some modern surgical instruments, syringes, needles, and a stethescope. The students viewed microscopic slides of some of the microbes which cause disease.

The cooperation of this parent and child in developing a science topic was best illustrated in the teacher-student conferences, for the student often would say, "Dad thinks we might be able to do this better if we did it this way," or, "Dad has shown me the following medical equipment and I may bring these things with me when I present my demonstration."

The father of one of the boys is a foundry worker and to-

gether, father and son, studied the historical development of the metal working industry in America. This interesting historical study was augmented by a demonstration of metal casting. In their home work shop they made a cope and drag and secured molding sand and a pewter mold.

At a recent parents' visitation night the father discussed the problem of metal casting with the teacher as enthusiastically as if he were the pupil developing the project.

A paper of this length will not allow for the description of all of the science topics; however, the following list of student demonstrations should show the wide variety of experiences that were offered these young people:

Weaving of cloth.
Microscopic observation of fibers of cotton, silk, and flax.
Chemical tests for cotton, silk, and flax.
Working model of a steam locomotive.
Working model of a steam turbine.
Experiments showing the behavior of static electricity.
Experiments showing the behavior of magnetic lines of force.
Microscopic observation of water, molds, and bacteria.
Printing.
Experiments illustrating the principles of buoyancy and stability.
Model sewing machine.
Weather prediction instruments—rain gauge, barometer, wet and dry thermometer, almanac.
Model cross-sections of various types of roads.
Flour as milled during the Colonial Period.
Guns of the Revolutionary War Period.
Models of typical Colonial farming tools.

Has the program been successful? The author feels that it has, for the students understood the purpose of their topics, they received training in planning, executing, and evaluating worthwhile activities under the guidance of their teacher, and they were able to present the results of their work to a group. They were tolerant of other people's ideas, they developed the ability to make observations and to draw conclusions from evidence, and gained an appreciation of the contributions of science to civilization. Furthermore, the author believes that true integration of science with all other subject matter in the curriculum has been achieved.

The integration of subject matter for the sake of integration may cause some educators to be wary of a program of unifying courses, but where integration is allowed to evolve naturally in a well planned curriculum, it provides a stimulus for both the student and the teacher.

# FOOD EDUCATION*

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Food education needs to become the concern of scientists and mathematicians. It may be true that eighty-five per cent of the buying in America is done by women but it does not follow that education in food should be the concern *only* of domestic science and homemaking instruction in our schools and the educational interest of women who are homemakers. The very condition of our economy now with its shortages and its surpluses of food, clothing, lumber, and other products of the land indicates that the basic philosophy underlying our agricultural economy is inadequate and that consumer-producer understanding and cooperation are yet to be achieved. This achievement involves all of our population and its relation to other agricultural countries. Education, the means by which children and adults acquire knowledge for their self-protection and use in society needs to include food education as a unit of instruction in a number of correlated subjects.

A recent examination of mathematics books for junior high school students revealed the very practical problems in food buying that can be presented and at the same time acquaint the student with the cuts of meat available in a carcass. This involves the practical use of fractions, pennies, scales, and values for different cuts while it provides an excellent beginning which only instructors who have the "know how" can finish.

During the past month of October, when the food situation was the main concern of the American people, Michigan teachers met in districts for their annual institutes. A review of those institute programs showed that discussion was concerned with topics far removed from food but still contingent upon its status in our national economy. The question of the need for increased salaries is an example. Food is a greatly misunderstood commodity in our country because it is not considered a fundamental educational interest by those concerned with the organization of school curricula.

While in Washington recently, it was my privilege to hear Dr. Boswell, Chief Horticulturist of the Department of Agriculture, give an illustrated lecture on the findings of a special

* An address before the Junior High School group of the Central Association of Science and Mathematics Teachers, Inc., Detroit, Michigan, November 30, 1946.

commission to Japan. The mission toured the different parts of that country to learn if the United States Department of Agriculture could be of assistance to the Japanese people in meeting their food problems. Slides in color of the different parts of Japan confirmed the mission's conclusion that our horticulturists and agriculturists can do nothing to assist the Japanese in meeting their local food requirements except to suggest better methods for fruit tree trimming. UNRRA in Japan is not a national need. The only assistance given to Japan in 1946 was a shipment of squash and pumpkin seeds because it had a short supply. These fruits are an important food item and are cultivated in unique ways not common to this country.

Agriculture in Japan, though crude in a number of ways, is modern in terms of America's agricultural practices. Conservation of the land by companion and successive cropping continually enriches the soil making it more valuable as the years go by—not less valuable as does common American farming practice, except in a comparatively few instances. Generally, only land that will produce three crops a year is used in Japan. Government order to use land which would not produce three crops failed in its purpose.

The Japanese farmer, living with and by the land, is occupied in his work throughout the year. Horticulture predominates in the Japanese agricultural pattern. Animal husbandry is not practiced extensively because the quantities of land available to the individual farmer cannot support both the family and animal life.

This short synopsis of Dr. Boswell's remarks may suggest only the agricultural and horticultural technique employed in Japan. A televised account would reveal to you some very fundamental food education, conservation, and applied scientific agriculture. It is not advocated here that a complete transplanting of their agricultural practices or economy be made in America, but that the "know how" to understand and appreciate food production, distribution, and use should become a part of the opportunities of boys and girls in America as much as the simple facts of mathematics or science.

In September, 1946, forty-seven nations met in the historic Parliament Building in Copenhagen, Denmark for the Second Session of the Conference on Food and Agricultural Organization of the United Nations to face the main problem of developing a long range food policy that affects every producer and

consumer. Today, it is estimated that two-thirds of the earth's population is underfed. Certainly the farmers in the world have a service to perform.

In meeting these food needs, what should we know? Is it sufficient to be content with what appears on the horizon at the moment—namely, expanding production, expanding markets, and expanding trade, jobs, better diets, and profitable business?

Some who believe that expanding agricultural production and jobs will meet the needs of the people view the future through rose colored glasses. There are others, closely associated with agriculture, who view expanding production with reserve and doubt. Many factors will prevent an expanding agriculture from being realized in the United States even though it has seven per cent of the world's agricultural lands, two per cent of the world's farmers, and produces twelve per cent of the world's food supply.

Here are some of those factors:

1. There are one million fewer farmers in America today than there were at the beginning of the war.
2. Economic conditions since the close of the war have prevented the return to the soil of veterans and others to replace those retiring from the land.
3. During the war and since its close insufficient farm machinery or replacement parts were manufactured. Interrupted industrial production and increased cost of the tools have made them too expensive for many farmers to purchase.
4. The ability to acquire equipment to operate the farm is a part of the picture but it has no economic advantage at existing price levels, therefore, it is of negative value to all society, both agricultural and industrial.
5. The mechanized farmer is still a biological being and not a superman.
6. Crop *prediction* and *production* are two widely separated matters—one makes news, and the other, food for the table.
7. An expanding production going beyond the war years is considered undesirable in terms of the land. Present financial returns from farm operations are not conducive to the practice of soil conservation.
8. Education for many years has failed to develop wide spread appreciation of conservation practices in agriculture. People in agricultural banking, industry, and business do not appreciate the means of solving the problems in agriculture through the application of wise land management.
9. Trained accredited farmers with the "know how" gained in our agricultural schools will not increase in number unless an incentive is provided by a modern application of agricultural finance.

The editorial staff of the *Country Gentlemen* in the November, 1946 issue has renewed the suggestion to President Harry S. Truman to proclaim 1947 a Soil Conservation Year.

The significance in the suggestion lies in the following ideas:

1. To obtain the food necessary to wage war, crop rotation and soil conservation practices were discontinued.
2. Some means should be taken to induce farmers to practice what is known to be best for the land.
3. The provident way of doing this is by a national soil-restoring and conserving program. It is better to store up productive capacity in the soil than to store surplus commodities in the granaries and warehouses under government loans. The basic capital stock of the nation would thereby be safeguarded for future requirements, which a growing population or new emergencies will impose upon it.
4. The approach to a better standard of living in America is a permanent agriculture giving all society a relative amount of security and to the farmers many of the service advantages now enjoyed only by urban people.

These comments may seem to be far removed from food education but let us get back to the things that are basic in providing food to the non-agricultural worker. The means of exchange is money. As mathematicians and scientists, are you familiar with the most recent discovery in natural law that has a relation to economics? It is known as the law of exchange which controls the whole complex system by which we live. Raw material income is the start of the cycle of exchange. It is the new wealth annually created by production. All other money involved in the process of manufacture and delivery to consumers is money temporarily borrowed from existing capital and returned to it when finished goods are sold. The national income is simply the amount of raw material income times the rate of turnover. The nation's wage fund, the manufacturing output possible, and the amount of public purchasing power are fixed by this turnover of raw material dollars.

Raw material comes from the land and the rate of turnover operates as an economic constant. Agriculture supplies 65 per cent of our raw materials and its income is the most sensitive and powerful part of this combination. This is true because farm income is distributed among a greater number of individuals and effects the buying power of vastly larger communities all over the nation. It is the dollar of agricultural income that has a large influence and a high rate of turnover. Thus, farm income appears to be the key factor in our system of making a living.

The study which revealed this natural law clearly showed:

1. That the national income will approximate seven times the total farm income.
2. That our national economic troubles have always come when farm prices fell out of line with other prices.
3. That during the depression years 1930–1941 consumers paid more

proportionately for food than during the previous decade. Less was produced and less was consumed. On the other hand, during 1943–1944 the share of the consumers' total income for food was the lowest in history.

Today, as you well know, the tentacles of the food octopus are fastened tightly on your pocketbook. It is too early to state accurately what the increased cost of living is in terms of food. It is here, again, that the fundamentals of an exact science are used to confuse Americans. Their knowledge of mathematics cannot be used intelligently in this problem because it is not supported by food education which, in its broader aspects, would give interpretation to the geography of America, its land, flora, fauna, and people.

This may sound exceedingly heavy for junior high school people to approach but that is the place for such learning to begin. The material required is a well trained instructor and some land, probably the cheapest educational layout a school can have. The combination of these two will permit children actually to contact the land and learn to love it before their minds are made up that soil is dirt which they should never lower themselves to touch. Most children at two years will make the soil or the sand in their playbox a part of their daily diet. Interest in this natural resource continues for a number of years. A simple effective approach which will give to almost every child an understanding and an appreciation useful in the problems of living is the cultivation of a garden. Garden education in a large way is the forerunner of good science instruction, both exact and biological. In fact, the food education I have been talking about needs the learning and interpretation that garden education can give to a child in a practical and academic manner.

Mathematics has always been helped by food products. "Two apples plus two apples," I am sure still is used to obtain early mathematical concepts. The significance of quantities of fresh food produced in a child's garden influences a young mind. Larger concepts of state or national food supplies are possible only through the use of mathematics. This larger significance can be completely appreciated when the small things that make the large things possible are experienced. The combination of soil, seed, and time are fundamental in the thinking and the understanding necessary in our economy. The misunderstanding of agricultural production in meeting a food supply plus much American propaganda to confuse the public mind created

an attitude which caused the people of the United States, November 5, to make use of the mathematical expression "x" to solve a national food and supply problem. What "x" equals has been learned only in part. No doubt "x" equals a complicated unknown including all economic factors. Surely, food education is one of the factors needed to solve this equation.

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## FELLOWSHIPS AND ASSOCIATESHIPS AT BATTELLE MEMORIAL INSTITUTE

For the year beginning in the summer or fall of 1947, Battelle Memorial Institute will appoint a limited number of predoctoral Fellows and postdoctoral Associates to conduct investigations of a fundamental character in the Battelle laboratories. This is a part of a training program which has been in operation at Battelle since 1931.

*Fellowships* are open to men seeking the Doctor's degree in a science or in engineering, and are available normally for the final year of graduate study. After completing his course work on the campus, a Fellow conducts his thesis research in the Battelle laboratories under a cooperative arrangement between Battelle and his university.

Fellows receive a stipend of $1200 a year, and they devote at least eleven months to their research. Funds are also set aside for supplies, equipment, supervision, traveling expense of the student and his faculty adviser, and publication costs.

In special cases candidates for the Master's degree may also be appointed, at a lower stipend.

*Associateships* are open to young men who have completed their academic training and have shown exceptional aptitude for research, either as graduate students or in subsequent employment. Preference will be given to those who hold a Ph.D. degree or who possess an equivalent command of their subject.

The applicant's objective may be to familiarize himself with Battelle's methods of conducting organized research, to learn a particular research technique, to develop a needed research tool, or simply to carry out a research program in one of Battelle's fields of specialization.

The stipend of an Associate is adjusted to his preparation, experience, and promise.

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## THE PRESIDENT'S CONFERENCE ON FIRE PREVENTION

Faced with an average annual toll of 10,000 deaths from fire, together with property loss which exceeded $560,000,000 in 1946, President Truman is sponsoring a nation-wide effort to cope with the fire menace.

The President's Conference on Fire Prevention is now past the formative stage and a volunteer staff is at work preparing for the meeting, which will be held May 6–8 in the Departmental Auditorium in Washington.

Representatives of municipal and State governments, Federal agencies, and of non-official organizations with a basic interest in fire prevention have been organized into a coordinating committee to draft an agenda for the Conference and to appoint committees which will prepare recommendations to be submitted to the Conference as a whole.

# THE HISTORY OF AIRPLANES

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As far back as we can go in history and mythology, we find references to flying. The Old Testament is filled with such references. The greatest reward that could be given to the faithful prophet, Elijah, was to be taken up from earth to heaven in an aerial chariot.

In Greek mythology, Phaeton drove the wild horse attached to the sun chariot of his father with such speed that the friction almost set the universe afire. The story of Daedalus, in the writings of Ovid, who made a pair of wings for his companion Icarus, and the misfortune which overtook the latter when, flying too close to the sun, the wax with which the wings were fastened to his body melted and he fell to the earth, is a well-known tale. In 400 B.C. a Greek mathematician, Archytos, invented a wooden bird which was said to have sustained itself in flight by means of "hidden air." Although no one succeeded in actually constructing a device capable of flight through the air until about 150 years ago, philosophers have continually speculated on the possibilities of flight throughout the ages.

Roger Bacon, a British philosopher, believed that the air had an upper surface, like a sea, on which a suitable form of flying apparatus could float. In 1250 he wrote: "Such a machine must be a hollow globe of copper or other suitable metal, wrought extremely thin in order to have it as light as possible. It must then be filled from some elevated point into the atmosphere when it will float like a vessel on water." It was not until 1670 that this idea was given further impetus. Francesco de Lana designed a "vacuum balloon" which was to be sustained by four large hollow metal spheres, from which all the air was exhausted. The metal spheres were held in fixed relation by a framework of wood and a boat or body was provided with oars and sails by which it was to be propelled. De Lana did not undertake the construction of his machine apparently because he feared that any attempt to navigate the air would be regarded as impious by the Creator.

The first well-authenticated sketches of Leonardo da Vinci are notable. He based his studies on the flight of a bird and constructed an aircraft with wings designed to flap. This type of aircraft, called an ornithopter-sustenation, is supposed to be

kept aloft by the flapping of the wings. No man-carrying machine of this kind has been successfully flown. For lack of motive power, da Vinci and his successors for nearly four centuries could do little more than invent. They could not navigate dynamic fliers, however ingeniously constructed. Da Vinci's first design provided the operator with two pairs of wings to be actuated by the power of both arms and legs. His second design was a helicopter; an aerial screw 96 feet in diameter was to be turned by a strong and nimble artist who might by prodigious effort lift himself for a short time. His third scheme of flight was a framed sail on which a man could ride downward, if not upward.

A Saracen, Elmerius, provided himself with a light robe which was fashioned in a flowing position by means of reed stays. In this regalia he jumped from a tower in Constantinople. The report is that he glided for a short distance, then lost his equilibrium and was killed in the fall to the ground. This probably was the first fatality ever resulting from a man's attempt to fly.

In more modern times some two score of pioneer experimenters endeavored to develop powered flight among whom were: Sir George Cayley, an English inventor, whose writings (1809–1810) show that he was the first to plan dynamic flight on a scientific basis. He designed an airplane built with a slightly oblique plane, resting on a wheeled chassis, fitted with propellers, motors, and steering devices. Samuel Henson, another English inventor, in 1843 patented what was designated as an "aerial steam carriage," an airplane of immense size which was to be used for passenger carrying. This carriage was never built. Another English scientist, F. H. Wenham, improved on Henson's idea and in 1867 developed a multiplane. This model was taken up by another inventor, M. Stringfellow who reduced the number of planes to three, making a triplane which was to be fitted with a tail and two propellers. In 1842 Stringfellow had already constructed a model in which the supporting force was obtained from the wings while the motive power came from a screw, and from that time on some of the fundamental principles underlying flight began to be more generally recognized. The triplane was shown by Stringfellow in 1868 at the exhibition of the Aeronautical Society of Great Britain at the Crystal Palace. He received a prize of £100 for this model. As in the case of previous inventors, nothing in this model indicated that he had any comprehension of the principles of stability or knowledge of the lifting capacity of surfaces, or of the power required for dynamic

flight. Stringfellow deserves, however, much credit for building a very light motor, one of sufficient lightness and strength to support a well-designed airplane.

These early experimenters laid the foundation of modern aviation. At the end of the 19th century, there were two distinct schools of thought. The first consisted of the exponents of gliding flight and included among its leaders, Otto Lilienthal, P. L. Pilcher, an English follower of Lilienthal, and J. J. Montgomery, an American pioneer. Lilienthal was the first to make gliding flight a science, and he first defined the value of arched wings, and the amount of pressure to be obtained at various angles of incidence. In 1890, Lilienthal in Germany began to have some success with gliders and in 1894 he constructed a so-called "air sailor" which flew. This glider was shaped like a huge bat, the umbrella-like wings being secured to a central member which had arm holes for the pilot. Diagonals of wood ran from this member, as well as brace wires secured to the wings. Lilienthal unfortunately was killed, but his experiments were carried on by one of his pupils, Dr. Chanute, who built a biplane and multiplane glider and whose assistance was of great value to the Wright brothers in their early experiments. These gliders were controlled by the pilot changing the position of his body and legs, thus shifting the center of gravity.

The second school of thought sought to develop powered flight as the solution of aerial navigation. The leaders of the second school, who actually built and tried power-driven airplanes, were Clement Ader, Sir Hiram Stevens Maxim, and Samuel Pierpont Langley. Clement Ader was the first to construct an airplane that would carry a man, but when two experiments proved failures, the French government withdrew its support. Meanwhile Sir Hiram Maxim was employed by the English government to construct a large multiplane, but his machine, fitted with two 175-horsepower steam engines proved a failure. The first really successful flight by a heavier-than-air model propelled by its own power was made at one of Professor Langley's aerodromes on May 6, 1896, at Quantico, Virginia, over the Potomac River. It flew for a distance of about one-half mile. The model was of tandem monoplane construction with four wings, and an over-all span of 14 feet. The tail section or rudders were set with springs and wires so that any change in direction caused the rudder to bring the machine back to a straight course and also maintain proper altitude. Professor

Langley, in 1903, constructed the first man-carrying heavier-than-air machine capable of flight. This machine was built with funds provided by the Army and was similar to the model described except that a wedge-shaped rudder was placed just aft of the pilot's car under the forward wing. This plane did not fly due to the failure of the catapult. Another early machine was that of Sir Hiram Maxim. The work of Maxim was chiefly with reference to the resistance of the air to plane surfaces, and the measurement of the force of screw propellers. His experiments were begun in 1889, and resulted in the building in 1893 of a multiplane driven by a steam engine with twin-screw propellers. This was the largest ever built up to that time. He proved that it was possible to make a machine which would not only sustain its own weight in the air, but carry an additional load as well, and that such a machine did not need a balloon of any kind to support it. His machine was not a practical success, but its construction was a milestone in the development of the airplane as many of his principles are used in present day practice.

## Man Learns to Fly

Two brothers, Wilbur and Orville Wright, lived in Dayton, Ohio. As boys they had been of an inventive turn of mind, and had enjoyed "making things that would run." One of their first enterprises, after leaving high school, was the publication of a small weekly newspaper, printed on a press which had been constructed entirely by themselves. In 1894 they were engaged in the job-printing business, and besides, they owned a bicycle shop, where these machines, which were then very popular, were manufactured. They first thought seriously about flying in 1896, when an account of Otto Lilienthal's death in an experiment with a glider came to their notice. Their discussion of this catastrophe led them to read all the books on flying which they could find. They were impressed with the great amount of material that had been written on the subject, and began to realize that flying was a very serious problem.

They found that there were two sets of theories about it, as described before—the theory of gliding flight and the theory of powered flight. The Wrights decided to follow the theory of gliding flight, partly because they were taking up the subject as a recreation rather than as a business, and hence did not wish to spend a large amount of money on it, and partly because they believed that the problem of equilibrium, or balance, in the air

was the most important question and should be solved first.

They built their first glider in 1900. It had two wing spans trussed with wire, with a total area of 165 square feet. Each wing was 18 feet long and 5 feet wide. It had a small plane placed in front which could be tilted by the operator and thus enable him to make the glider go up or down. It also had a device for warping or twisting the ends of the flexible wings, giving the same effect as was later obtained by the ailerons. They used spruce wood for the wing spars and strong muslin for the outer covering. They also curved the wings, but to a lesser degree than that specified in the tables of Lilienthal, who had shown that curving the wings gave them a much greater lifting power than flat wings possessed.

After completing their design, they wrote to the Weather Bureau in Washington for information as to a location where they might find a steady wind of at least eighteen miles per hour. They were told that there were many such places along the Atlantic coast. They selected Kitty Hawk, North Carolina, as a place suited to their requirements, for it not only had the wind which they needed but also high sand dunes which would furnish ideal runways for taking off.

Late in the summer of 1900, they assembled their machine at Kitty Hawk and flew it first as a kite, as they could thus observe its performance without danger. Afterward they made a few gliding flights, and although the plane would soar in the air, it was hard to control. Its chief defect was that it would not fly level in the wind, even when the pilot shifted his position constantly to balance it. But they were pleased to find that the elevator worked, and that the warping of the wings helped to stabilize the machine. Although they had actually been in the air but a few minutes, the results were so encouraging that they decided to build another glider and test it at Kitty Hawk the next summer.

Their second glider was larger than the first, the wings being 22 feet long and 7 feet wide. The curve of the wing was increased to conform to Lilienthal's tables. They made a flight of 300 feet late in July, but the plane was so hard to control that the utmost skill was required to keep it from diving to the ground. In order to find out the trouble, they removed the upper wing and flew it as a kite. From this experiment they concluded that the wing curve was at fault, and they changed it to conform to their first glider. At the end of the summer of 1901, they were

almost ready to give up their attempts, as they felt that the results did not justify the time and money they were spending. However, once back in Dayton, they found themselves unable to drop the subject. They began to go more deeply into the study of wind pressure and to examine all the figures which had been published on the subject.

It was during that winter that they built a wind tunnel, the first one ever constructed. It was a square tube 16 inches across and 6 feet long. It had a fan at one end to produce the air current. By this means they tested small wings, from 3 to 9 inches in length, cut out of sheet metal. This patient research work gave them many useful facts about the shape and curvature of the wings, and they began with renewed confidence to plan a third glider.

This machine had wings 30 feet long and 5 feet across. They flew it first, as they had done with previous models, and then began going up in it. They found it more stable than the others, and capable of flight under almost any condition of wind and weather. Their flights were short, usually not more than five or six hundred feet, but they were learning the reasons for failure and acquiring scientific data of the utmost value in their future work. They were soon planning a machine which would be equipped with an engine and propeller instead of having to depend on the wind as motive power.

The airplane which is credited with the first flight carrying a man in an engine-driven craft was constructed by the Wrights, engine and all. They planned to provide for the carrying of 600 pounds total weight, with an engine of eight horse-power. They also designed the propellers, basing their design on the theory of marine propellers. Two propellers were used, in order to secure the benefit of as large a quantity of air as possible. These were driven by chains. Skids similar to sled runners were used to aid in taking off. The plane itself was similar to the glider which had flown so successfully in 1902, except that it was slightly larger.

It was late in the season of 1903 when the machine was finally assembled and ready for flight. The weather was unfavorable, the wind being unusually strong. When they were ready to attempt a flight, they tossed a coin to see who should first act as pilot. Wilbur won, but when they tried to launch the plane into the air, something went wrong, and it settled to the ground. Minor repairs were necessary, and it was three days before another flight could be attempted. This time it was Orville's turn,

and he had better fortune. On December 17, 1903, he made a short flight, lasting only twelve seconds and covering a distance of about 120 feet. But it was enough to convince the brothers that they were on the right track. They made three more flights that day, although the wind continued to blow a gale. Toward evening a strong gust struck the plane and turned it over on the ground, causing damage which prevented any more flights that year.

The problem of human flight was solved. They returned to Dayton, established a flying field a few miles from town, and began a new series of experiments which made flying a common sight in the neighborhood. The brothers then gave up their other business interests and devoted themselves entirely to the development of the science of aviation.

People generally paid little attention to this epoch-making flight at the time. Few knew of the event, or believed that it had actually been accomplished. Only in recent years was the world awakened to the significance of their achievement and begun to accord to Wilbur and Orville Wright their well-earned place in the list of humanity's benefactors.

A subsequent machine built by them in 1908 was so successful that it was accepted by the United States army and used for the instruction of officers in the art of flying. From that date forward the army and navy departments of the United States and several European nations became important agencies for the improvement of the airplane. Problems of design and construction were gradually transferred from the field of invention to that of engineering; that is, originality of conception was not so much sought after as the principles underlying the construction of flying machines with stability, speed and control; and by the beginning of the World War in 1914, airplane flights were definitely established as practicable.

During World War I knowledge of aeronautics was confined rather narrowly to the military types of airplanes of which several were developed—combat, bombers, pursuit—some carrying machine guns and others having armored bodies. Out of this war there issued an airplane of vastly superior efficiency.

Up to and during the war airplanes were made almost exclusively of wood, because it has a high strength-weight ratio and is a natural and easy medium for experimental construction. But only special straight grained woods were suitable for aircraft and the vast demand for airplanes during the war soon de-

pleted the supplies to such an extent that the various governments and private concerns began to experiment with the replacement of wood by metals, particularly aluminum alloys. Dornier, in Germany, was among the very first to apply duralumin to his ships. American builders embraced metal construction rather slowly and although military planes designed by Grover Loening of the Sturtevant Airplane Company in 1916 had all-steel fuselages, it was not until Fokker exhibited his welded steel fuselages in the United States in 1922 that metal construction came to the fore in America. Today, such machines as the Douglas DC-series and the Boeings are made completely of metal and even the small private machine has turned to metal as its chief constructional material. Metal has prevailed not only because of its safety and high strength but because it has the qualities of durability and long life.

After World War I, aerial passenger lines began to be established on several routes in Europe and the United States and aerial mail service was successfully inaugurated. The Atlantic was crossed in a non-stop flight in 1919 and in 1923 American Army officers made the first non-stop coast to coast flight from Long Island to San Diego, California. In 1924 the American Army officers flew around the world. Finally in 1927, Charles A. Lindbergh's non-stop flight from New York to Paris startled the world into recognition that aviation had become an established fact.

## The Modern Airplane

In 1909, the Wright Brothers had delivered to the United States Army the world's first military airplane. In 1939, on the thirtieth anniversary of the event, was inaugurated the greatest peacetime expansion of the air corps in the history of the United States. With the entrance of the United States into World War II, plans for greatly increasing the training programs for air and ground crews were put into effect, and orders placed for tens of thousands of military airplanes of all types. The heavy bomber emerged as the primary long range offensive weapon. During 1942, the first year of an all-out world-wide air war, few new or novel military aircraft came into active use. Although newspapers and magazines were full of talk of "secret weapons" or of super aerial battleships, no radical departure from the conventional appeared to give its possessor unquestioned superior-

ity in the air. Designers and builders everywhere were constantly changing details in an effort to satisfy the constantly changing needs of the tactical groups.

Germany declared war in 1939 only after she had built up an air fleet large enough (as she thought) to guarantee success by the blitzkrieg method. The tactical squadrons in the field were backed up by a production of standardized types sufficient to take care of the necessary replacements for a supposedly short war. Research and development were not entirely neglected, but became secondary to production. Only after it became evident that the war was not to be won in 1940 or 1941 was great stress put on retooling the German aircraft industry for the production of machines that had been laid down on drafting boards, or tested in laboratories after the war started.

The same situation obtained in Britain. When war came, Britain had far fewer aircraft in the field than she needed. Further, the destructive raids of 1940, together with the terrific attrition of the Dunkirk period, compelled her to concentrate all her efforts on the production of types that had been designed and developed during the years immediately prior to the war. Only after the relief afforded by the rehabilitation of her own factories, and by the operation of lend-lease, was Britain able to divert engineering talent into the development of aircraft designed to outfly the faster and more powerful ships that soon were flowing from Germany's revamped factories.

Before the war, many British experts had been openly skeptical of the big four-engined bomber—a distinctly American development. It was argued that its size and lack of maneuverability would make it an easy target for interceptors. The British found, however, that the giant bomber, when used at night could carry tremendous bomb loads at reasonable ranges.

At the close of 1943, came the first public hint of the nature of some of the expected surprises. It had long been known that all first-rate aeronautical powers were experimenting with rocket or jet types of propulsion. The veil of secrecy, heretofore drawn tightly about all such projects was lifted a little in 1943. The so-called "sustained jet" type of propulsion was the novelty announced in the press at the end of the year. It replaced entirely the conventional engine and propeller combination. This type of airplane is built around an open-ended tube. Air is sucked in at the forward opening, compressed in a blower, heated by engine exhaust gas or by open gasoline burners, and

blown out the stern opening. The reaction to the hot air blast provided the thrust to drive the plane forward.

The first public disclosure of this type came in 1941 when the Italian-built Caproni-Campiani CC-22 flew from Milan to Rome. Its performance was not impressive but it proved to be a prototype for later development. The jet plane never attained a telling stage in Italy because of the relatively early capitulation of that country to Allied armies.

Other nations adopted the war-born development, with Germany attaining the lead in the production of jet planes. High militarists have asserted that if Goering had concentrated on production of these planes, in which he had a head start, instead of the fiendishly murderous robot bombs, the Nazis could have prolonged the war.

Today the prediction is made that man will one day circumnavigate the globe in 12 hours by development of jet propulsion engines. Many factors must be considered and met before man can ever fly around the world between sunrise and sunset, with the chief obstacle perhaps being inability of man to stand the physical ordeal of intense and prolonged speed.

It would take a hardy prophet to attempt to forecast in detail the course of aviation in the years that lie ahead. It is safe to say, though, that there is no limit to the new vistas that may be opened up for those who fly.

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NATIONAL BOYS AND GIRLS WEEK will be observed in nearly every community in the United States from April 26 to May 3, 1947. The celebration will mark the 27th annual observance of this important youth event.

With the theme, "Youth—the Trustees of Posterity," the program is designed to focus the attention of the public on the problems, interests, and recreations of youth, and on the part played by the home, church, school, and youth-serving organizations in the development of character and good citizenship in growing boys and girls.

# DARWIN VERSUS EXPERIMENTAL BIOLOGY

William J. Tinkle
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The Natural History Society of Brunn consisted of men who should have been able to understand the work of their neighbor, Mendel, but their minds must have been on other matters. At least, in his biography[1] of Gregor Mendel, Hugo Iltis relates that there was no discussion following the reading of Mendel's report on the breeding of peas, the paper which actually revolutionized the science of genetics. Later on in the same meeting, however, mention was made of a new book entitled *On the Origin of Species*, written by an Englishman named Darwin.

This was in 1865, and during the balance of that century Charles Darwin held the center of the stage, the attention of the scientific world being centered upon him. Mendel's paper rested on a shelf in oblivion until in 1900 it was discovered independently by Correns, DeVries, and Tschermak. Darwin himself probably never heard of Mendel, for Darwin's son looked through all of his books and found no mention of the great geneticist.

Hero worship usually is associated with children or with primitive people; yet we biologists are enough like the common herd that we follow in their train. We claim to be so objective that we are influenced only by facts and not by emotional attitudes, but in spite of our claims we worship Darwin. This attitude might be passed by, were it not that it hinders our acceptance of ideas that are up to date.

The landlord of Down Manor was a good man, of gentle spirit, and a very agreeable type of person. While he had boundless love for nature he enrolled in but few basic biological courses, learning incidentally of nature while studying medicine and theology. Darwin wrote very interesting accounts of his travels, of earthworms, and of clover pollination, but his fame does not rest upon these. He is remembered because he induced many people to believe in evolution, which the scholars of "The Enlightenment" had advocated in vain. This he did by giving an explanation of the method of evolution which then

[1] Iltis, H.: *Life of Mendel* (Trans. by E. and C. Paul); 1932.

seemed plausible. Yet at present our best scientists say we still are searching for the method of evolution.

Johannsen of Denmark set out to illustrate Darwin's principles but in the end he revealed a limitation.[2] In a plot of Princess bean plants that had descended from a single seed, he selected the heaviest and also the lightest beans. The mean weight of the large beans was 70 centigrams; of the small ones, 40 centigrams. Planting these two groups of seed in separate plots the next season, Darwin would have expected that the heavy beans would produce beans averaging more in weight than from the small ones, but the result was quite otherwise. Johannsen found that the progeny of the heavy beans averaged 55.5 cg. and the progeny of the light beans practically the same, namely 57.2 cg. These results have been amply verified so that now we know that selection is not effective in a pure line of beans or of any other species. Those who follow Darwin exclusively tend to think that selection creates new varieties, but Johannsen showed that selection creates nothing, and can only sort out what already is there. The beans in the experiment differed in size because of difference in position, not because of difference in innate potentiality. In other words we are dealing here with an acquired or environmentally produced character, which is not inherited.

No one claims to believe in the inheritance of acquired characters today but it crops out in the writings of more than one. For instance the origin of bird migration is accounted for by the inheritance of a habit.[3] It is assumed that the species which migrate annually came originally from a southern region and the autumn flight is simply a return home. In the nineteenth century, which was marked by armchair reasoning, fluctuations caused by the environment were thought to be inherited; but the experimentation of the twentieth century has proved that they are not.

The purpose in citing this author and the following ones is not to discredit them for they are leaders in their respective fields. But they are mentioned as examples of trends into which all of us tend to fall. We tend to accept with religious fervor the ideas of our favorites, whereas we should hold them only tentatively so that we can revise them when research reveals knowledge that is more complete.

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[2] Johannsen, W. L.: *Elemente der exacten Erblichkeitslehre*, ed. 2, Jena, 1913.

[3] Allen, A. A.: *Book of Bird Life*, p. 113; 1930; D. Van Nostrand.

In a biology text book bearing the date 1941,[4] mutations are "Neo-Darwinism," as if Darwin had described them; but he did not even mention them except under the loose name of "sport." One of the most serious weaknesses of Darwin and of most men of his day was that they lumped together mutations, chromosomal aberrations, acquired characters, and segregations, giving the same discussion for all of them, and for this reason no valid genetics could be written. In the index we find listed *bat* and *Beagle* (a ship in which Darwin sailed) but no mention of Bateson, the great English biologist. In the description of mutation under the name of "Neo-Darwinism" in the book cited, no mention is made of Muller, Goldschmidt, Bateson, nor even of Morgan; and De Vries is not given the credit he deserves. This certainly is a failure to teach twentieth century science, and the reason for the failure is hero worship. We used to wonder why churches proclaim certain men saints, but we biologists certainly have our own.

What kind of attitude is it that gives a man credit for his mistakes and refuses to recognize the one who corrected him? In another textbook[5] Darwin's hypothesis of pangenesis is related, which postulated that the germplasm of an animal is built up of tiny gemmules from all over the body, assembled by the blood stream. This was an ingenious method of accounting for the inheritance of acquired characters, which scientists of our day do not believe to be inherited at all. In the text book cited, more than a page is devoted to this hypothesis and its author, with no mention at all of how it was disproved by Francis Galton by transfusing blood in rabbits. At this point the present author also must plead guilty, for in his book[6] he also failed to give credit to Galton. Hero worship in general glorifies the past and closes our eyes to the splendid investigations of later men. It is true that those who quote our findings are farthest behind; namely the psychologists and sociologists. But we are to blame if we make it even harder for them to quote the latest biology.

Darwin said changes are small, that they occur universally, and that with the selection of nature they gradually but surely improve the species. Based upon his claims, some scholars have contended that if only men had patience enough to keep from meddling with nature the world would outgrow her problems.

[4] Mavor, J. W.: *General Biology*, p. 790; Macmillan.
[5] Holmes, S. J.: *Int. to Gen. Biology*, p. 303; 1926; Harcourt, Brace.
[6] Tinkle, W. J.: *Fund. of Zoology*, p. 105; 1939; Zondervan.

But horticulturists find that a garden when left to itself is taken over by weeds, and geneticists find that improvement in breeding is the result of planning and long-continued effort toward a goal. Our public at present is in no mood to accept an easy, rosy optimism, but is realistic and even pessimistic. We do not build up the prestige of biology by insisting on attitudes of the nineteenth century that are not highly esteemed by the best investigators of the present day.

The scientific attitude is a high ideal and not the easiest of disciplines. Let us try harder to live up to our profession and avoid hero worship.

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## IT IS FUN TO KNOW ABOUT BIRDS

Introduce your class to the out-of-doors this spring by forming an AUDUBON JUNIOR CLUB: Audubon Junior Clubs are nature clubs sponsored by the National Audubon Society to teach children through bird study to discover some of the wonders of plant and animal life and to awaken their interest in the conservation of wildlife and other natural resources. A special endowment for these clubs enables the Society to supply its clubs with the following interesting materials:

*Every Child receives* a membership button, 6 four-page bird leaflets illustrated with line drawings and describing habits of the bird throughout the year (available in two editions—*Junior* with large type and simple text for grades below the sixth, *Senior* with smaller type and longer text for grades six and above), 6 color plates of birds ($5\frac{1}{2} \times 8\frac{1}{2}$), 6 outline drawings of birds to color.

*Every Club receives* NEWS ON THE WING, the Junior Club paper—three spring issues. The paper contains pictures, puzzles, news items, stories contributed by club members, and many suggestions of things to do.

*Every Club Adviser, the teacher who forms the club, receives* AUDUBON TEACHERS GUIDE—a special booklet, attractively illustrated and containing many suggestions for nature adventures to be experienced outdoors and in the classroom. The Guide explains how to make bird houses, bird feeders, bird calendars, take field trips, plan good club meetings, describes plant and animal habitats, discusses the protection and conservation of American wildlife and contains a good bibliography of nature books.

It is easy to form an Audubon Junior Club. Any group of *ten or more* children of elementary, junior or senior high school age may form a club. Each club has an adult adviser, the teacher. Club dues are ten cents per member for the school year and are paid to the club adviser who mails the combined club dues, together with her name and address, to *CHILDREN'S CLUBS, National Audubon Society, 1000 Fifth Avenue, New York 28, N. Y.*—being sure to state how many sets of Junior or Senior edition leaflets are needed.

Clubs may enroll at any time during the school year. Enroll early and enjoy as many weeks of fun as possible.

# TOMORROW'S SCIENTISTS*

WATSON DAVIS

*Director of Science Service, Washington, D. C.*

*Tomorrow's scientists will create tomorrow's science*

The scientists of tomorrow are among the thousands and thousands of boys and girls now in school. It is of utmost importance to the world that those who are capable of creative scientific careers should have the opportunity of an early acquaintance with the materials of science and technology. They must understand what science is about, how it works, what it can do. Above all, they must be given a chance to do with their own hands and brains simple scientific projects which will provide the practice and inspiration basic to a scientific research career.

Only a relatively few thousand among the millions now in school will be the scientists of tomorrow. But it is important that the millions now in school have some understanding of the methods and the possibilities of science and technology. If they do not understand, they will not be able to give the proper support to scientific research and they will not be able to utilize the fruits of scientific research as they should be used for a peaceful and progressive world.

The importance of science in our schools is greater than ever before in the history of our democracy. There should be an increasing amount of science activity without the school room as well as within the school room. Science clubs, where science projects are pursued as a hobby, should play an increasingly important role in science education. The teacher who sponsors science clubs continues and augments in an important way his formal teaching.

During the war, fundamental development of scientific abilities was largely sacrificed just as fundamental research in science was sidetracked for developments of actual weapons. These are among the evils of war which must be corrected. There must be thousands of boys and girls being given the opportunity of becoming tomorrow's scientists, capable of doing the fruitful scientific research upon which tomorrow's progress will be based. We must be confident that there will be a scientific way found

* Address before the Central Association of Science and Mathematics Teachers, Friday morning, November 29, 1946 at Detroit.

to prevent atomic wars of the future which will negate progress. We must be confident that science provides the strength and the foundation for a better peaceful world, just as it has provided deadly weapons of offense and defense in time of need.

## THE QUIZ SECTION

Julius Sumner Miller
*Chapman College, Los Angeles 27, California*

1. The density of hydrogen is about 0.0899 gm./liter; the density of helium is about 0.178 gm./liter. That is, hydrogen is only about half as dense as helium. Does this mean, then, that the lifting power of a balloon filled with hydrogen will be TWICE that of a balloon filled with helium? (Show, in fact, that it offers only 8% more buoyancy!)
2. If the moon were twice as far from the earth as it now is, what would be its period?
3. A steel wire one mile long hangs vertically supported at its upper end. How much does it stretch under its own weight?
4. Assuming no friction during fall, from what height must a chunk of ice at 0°C. be dropped so that all the energy at impact just melts it?
5. An object floats on the surface of a liquid, the whole system exposed to the atmosphere. If now the air above the liquid be evacuated (using a bell-jar, say), will the object remain at its original depth, will it sink, or will is rise a bit?
6. Suppose there is a steel band which fits EXACTLY around the earth at the Equator. Now let us snip this band at some point and insert a piece 3 feet long. Now fly around the earth on a magic carpet! and lift the band away from the earth so as to take up the slack evenly. How much distance will there now be between the earth and the band? Do you think a boy could crawl under it? Or maybe water would just trickle through!!
7. Two men are walking towards each other at the same rate. A train passes the first man in 10 seconds and 20 minutes later passes the second one in 9 seconds. How long after it passed the second man did the men meet?

(Send solutions to Julius Sumner Miller. Names of solvers will be published.)

## WARD'S ISSUES NEW ENTOMOLOGY CATALOG

Complete supply services in entomology for secondary school teachers, students and collectors are offered in a special 1947 catalog issued by Ward's Natural Science Establishment of Rochester, N. Y.

Useful in itself as a teaching aid and collector's guide, the catalog pictures and describes equipment for collecting, mounting and displaying insect specimens; some of the items have only recently become available after a protracted wartime shortage.

The catalog lists a special selection of specimens with which beginners may start or complete their collections of insects, especially those from foreign lands. Books and manuals in entomology, ranging from beginner's guides and general literature to publications on special phases of the subject, are listed and briefly reviewed in the catalog.

# EASTERN ASSOCIATION OF PHYSICS TEACHERS

## ONE HUNDRED SIXTY-FOURTH MEETING

**Joint meeting with the New England Association of Chemistry Teachers and the New England Association of Biology Teachers**

**Saturday, 7 December 1946**
**Boston College, Chestnut Hill, Mass.**

9:45 Greeting by the President of Boston College
10:00 Address: Some Impacts of Biology, Biochemistry, and Biophysics on the Problem of the Nature and Formation of Connective Tissue Dr. Bernard S. Gould, Massachusetts Institute of Technology
11:00 Address: The Physics of Precipitation in the Atmosphere Mr. Roland J. Boucher, United States Weather Bureau
12:00 Address: Application of Science in the Detection of Crime as used in the F. B. I. Laboratory Mr. Jeremiah F. Buckley, Federal Bureau of Investigation
1:00 Luncheon
2:00 Tour of the Chemistry, Physics, and Biology Laboratories
2:30 Apparatus Committee Report
3:30 Business Meeting

## THE PHYSICS OF PRECIPITATION IN THE ATMOSPHERE

Roland J. Boucher, *U. S. Weather Bureau, Boston, Mass.*

Ever since the days of Aristotle, there has been much conjecture regarding the theory of precipitation in the atmosphere. One of the earliest plausible theories was that of Hutton, a British geologist of the 18th century; he believed that rain was produced by the mixing of humid masses of air having different temperatures. His ideas were based on the fact that the capacity of a mass of air to contain water decreases more rapidly than in direct proportion to the temperature. The following table, giving the saturation specific humidity for certain temperatures, shows the number of grams of water vapor per kilogram of saturated air at a pressure of 1000 millibars:

| | | | | | |
|---|---|---|---|---|---|
| −40°C | 0.11 | 0°C. | 3.80 | 20°C. | 14.7 |
| −30 | 0.32 | 5 | 5.44 | 25 | 20.0 |
| −20 | 0.78 | 10 | 7.67 | 30 | 26.9 |
| −10 | 1.79 | 15 | 10.7 | | |

From this it can be seen that when two masses of air, both saturated and of different temperatures, are mixed, the mixture is too cold for it to hold all the water vapor originally contained by the separate masses. Consequently some of the water vapor must drop out either to condense as a cloud or as precipitation. While it is perfectly true that a small amount of precipitation might be realized from such a process, it does not occur on a large enough scale to account for even a light rainfall, not to

mention the innumerable cases when the two conditions of saturation and temperature difference are not satisfied. It might also be added that the release of the latent heat of condensation would tend to raise the temperature of the mixture and hence lessen the amount of precipitation possible. Yet in spite of its shortcomings, this theory of the formation of rain was accepted for about 100 years, or until near the end of the 19th century.

The next concept of the primary cause for condensation and precipitation was that of dynamic cooling in ascending air currents. As the air rises it expands because of reduced pressure, thereby lowering its temperature. The amount of water condensed is limited only by the amount of moist air lifted sufficiently to cool it below its saturation temperature. This cooling process is generally considered to be adiabatic. In case you have forgotten, that means there is no heat exchange between the air undergoing the cooling and the environment. This theory, which seems to agree very well with observed phenomena, is the one which we hold today, and Dalton the great physicist is generally accepted as the first to mention it in his writings.

Here are a few examples of how a moist current is lifted to cause cooling and condensation:

1) Convection as in summer showers and thunderstorms.
2) Forced ascent of moist air current over a cold wedge (a warm front). When this sort of action stagnates over a given area it may cause flood situations.
3) Lifting of warm moist air by undercutting cold air (a cold front). In this the cold air is the active element, whereas in the previous example the warm air is the aggressor.
4) Orographic lifting of moist air. When an air current is forced to pass over a mountain range, the air is cooled just as in any other type of lifting and, if the cooling reaches the saturation temperature, condensation will occur. Extreme examples of condensation and precipitation resulting from this sort of lifting are the torrential rains of the Himalayan foothills of India, where as much as 40 inches of rain has been known to fall in a single day (more than Boston's normal rainfall for a whole year).

Just for the sake of completeness there are two other ways in which condensation may occur, although neither of them can produce precipitation. These are cooling of moist air by (1) radiation to space and (2) by contact with a cold surface. These, and especially the contact cooling process, are particularly important in the formation of fog; illustrations are the cooling of warm moist air over cold water or over a snow surface. Usually fog results as a combination of these processes. On a clear night the surface of the earth, especially grassy fields or better still a snow surface, will radiate heat very rapidly to outer space and become much cooler than the air just a few feet above the ground. The air then in turn is cooled by contact with the cool surface, and fog will form when the saturation temperature is reached.

For a long time condensation and precipitation were confused and the words were even used interchangeably. It was believed that if conditions were sufficient for intense condensation, there should immediately follow intense precipitation. But this did not agree with observed facts, for there is much cloudiness which fails to produce any precipitation; in fact clouds may continuously cover the sky for days on end with no precipitation whatever. It was finally realized that some sort of release was necessary to start the process of precipitation from existing cloudiness. Before we examine the hypotheses dealing with this mechanism, it might be well to go over a few fundamental ideas on condensation.

It has been proven beyond reasonable doubt that atmospheric condensation cannot occur on a wholesale scale without nuclei of condensation. Condensation without the help of nuclei would require a tremendous degree of supersaturation in the atmosphere far beyond any value ever observed. The reason for this is that, owing to the effects of surface tension, the vapor pressure over a convex surface is greater than that over a plane surface by an amount which varies inversely with the radius of curvature; for a very small drop the vapor pressure becomes excessively high. For this reason it is impossible for a drop to form as its vapor pressure would approach infinity at the start of its existence. This is quite evident from the following expression for the difference in the vapor pressure near the drop from that near a plane surface:

$$P_1 - P_2 = \frac{\sigma}{\rho - \sigma}\,\frac{2T}{r}$$

where: $P_1$ is the vapor pressure near the drop
$P_2$ is the vapor pressure near the plane surface
$\sigma$ is the density of the vapor
$\rho$ is the density of the liquid
$T$ is the surface tension of the liquid
$r$ is the radius of the drop of water.

Fortunately there are present in the atmosphere at all times an abundant supply of hygroscopic nuclei which consist for the most part of fine salt particles. These hygroscopic particles not only furnish nuclei of finite size for the droplet to start on, but their attraction for water allows condensation to begin at considerably lower vapor pressures than would otherwise be possible. Depending upon the nature and size of these particles, it may be possible for condensation to begin at relative humidities as low as 97%. Because of the lower vapor pressures required for condensation on convex surfaces of relatively large radii of curvature, condensation will first take place on the larger nuclei. The smaller ones which require a greater degree of saturation, will become active only if there is an insufficient number of the larger nuclei present.

The rate of growth of the droplets varies as an inverse function of the drop size according to the following expression:

$$a^2=A^2+8K(D-D_0)t$$

where: $a$ is the drop diameter at time $t$
$A$ is the initial drop diameter
$K$ is the diffusion coefficient of water vapor in air
$D-D_0$ is the difference between water vapor density in the atmosphere and at the surface.

Using this expression, we find that two drops initially of 0.2 and 2.0 microns diameter respectively will reach a size of 10.0 and 10.2 microns at the same time. The nuclei vary considerably in size, but because of the change in rate of growth as the droplet size increases, all drops tend to reach their maximum size at about the same time. This property produces clouds with a fairly uniform droplet size which, as we shall see, is a deterrent to precipitation since it prevents amalgamation of the droplets to the size necessary for rain. The maximum size of the droplets formed by condensation is limited by the amount of the water available. This is generally considered to be on the order of 50 microns in diameter.

Summarizing what we have covered so far: the condensation process leads to the formation of a large number of relatively small drops which tend to be of uniform size for a given set of conditions, i.e. amount of vapor available, and altitude. But condensation alone could never yield precipitation because the large number of nuclei present would form more cloud particles, resulting in a denser cloud. It is evident therefore that there must be some mechanism whereby the cloud elements or droplets amalgamate to form drops which have a sufficient fall velocity to overcome the rising current necessary to maintain the cloud and to fall as rain. To give an idea of what these sizes are and their respective fall velocities here is a short table:

| | diameter | fall velocity |
|---|---|---|
| mist | 0.1 mm | 0.25 m/sec |
| drizzle | 0.2 | 0.75 |
| light rain | 0.45 | 2.00 |
| moderate rain | 1.0 | 4.0 |
| heavy rain | 1.5 | 5.0 |
| very heavy rain | 2.1 | 6.0 |
| cloudburst | 3.0 | 7.0 |
| maximum possible | 5.0 | 8.0 |

(Drops larger than 5 mm will break up into smaller drops; only hailstones can be larger.)

This now leads us to the actual formation of precipitation from condensed water vapor. As can readily be imagined, this process is very difficult to study; most of the knowledge about precipitation must be deduced from what can be observed and measured at the surface of the earth, while the process takes place several thousand feet up. Meager as our knowledge is, a fairly workable theory has been put together—but there are still many points of uncertainty and much room for further study and research.

The water vapor condensed into cloud form can be regarded as a colloidal suspension of water in air. This suspension may be *stable*, in which case the droplets do not coalesce and there is no precipitation, or it may be *unstable*, in which case there is droplet coagulation and subsequent precipitation. The conditions under which a cloud will remain stable (and you will remain dry under it) are as follows:

1) A uniform electrical charge on all the cloud droplets, i.e. a charge of the same magnitude and polarity. This will cause cloud droplets to repel one another as they come close together and prevent amalgamation.
2) A uniform size of cloud droplets. As we have seen, the condensation process results in cloud droplets of nearly the same size. This means that the droplets will all have the same fall velocity and hence no danger of coalescing by having some drops overtake others.
3) A uniform temperature of cloud elements, so that there exists no appreciable difference in vapor pressure between one part of the cloud and another which might cause some of the droplets to grow at the expense of others.
4) A uniform motion of cloud elements which implies lack of turbulence which might force collisions between droplets and result in amalgamation.

The non-fulfillment of any of these conditions will result in colloidal instability which, if of sufficient magnitude, will cause the droplets to coalesce and result in precipitation.

There is considerable evidence to show that raindrops result principally from coalescence of cloud particles and that little, if any, rain results from the growth of certain particles at the expense of others. The analysis of rainwater shows that the chloride concentration (salt nuclei) is practically the same as that in cloud water. If selective growth occurred on any large scale, the rainwater should show a weaker concentration. A German meteorologist, Defant, who measured over 10,000 raindrops found that their masses are integral multiples of a standard size, showing that the larger drops were probably formed from smaller droplets.

It seems logical to assume that the most rapid coagulation should occur from collisions between particles of unlike size, which because of their different size will fall at different velocities; the larger will overtake the smaller and will also coalesce with all the drops in its path unless carrying high electrical charges of opposite sign. To illustrate this process, let us assume that a cloud contains one gram of liquid water per cubic meter, consisting of droplets 20 microns in diameter formed by condensation on hygroscopic nuclei. By collision between a few droplets, probably through turbulence within the cloud often observed, a number of 25 micron drops form. These will immediately begin to fall relative to the 20 micron drops and in eight minutes will attain a diameter of 100 microns. With only an additional fall of 1500 feet through the cloud, the 100 micron

drops will grow to one millimeter; drops of this size are classified as moderate rain. It is evident from this example that the rain forming process once the conditions have been established is a very rapid one. The final size of the drop after leaving the base of the cloud will depend on four factors:

1) The size of the original cloud particles.
2) The liquid water content of the cloud.
3) The depth or vertical thickness of the cloud layer through which the drop falls.
4) The vertical velocity of the ascending air current which is essential to produce the initial condensation. The higher this velocity, the longer the drop will remain in the cloud and the larger it will grow. This probably accounts for the very large drops which are often observed at the beginning of a summer shower or thundershower. The very strong updrafts which are characteristic of these storms will often hold the drops in the cloud and allow them to reach their maximum size before falling to the ground.

There are two other possible causes of coalescence of cloud particles. These I will mention briefly for the sake of completeness, but they are considered unimportant for the reason that they are much too slow in action. One of these is the hydrodynamical attraction between two drops of equal size falling side by side. This is a real force and does probably account for a small amount of coalescing but it would require too much time to produce an appreciable amount of precipitation. There is also the molecular impact upon the droplets produced by Brownian Movement which may result in a few collisions of droplets—but this has been observed in the laboratory and found to be inappreciable on the case of cloud drops.

Among the most recent theories on the physical process of precipitation is one proposed by Bergeron, a Norwegian meteorologist, and Findeisen, a German physicist, in the thirties. The main feature of this more recent theory is that it incorporates an explanation of the sudden release of precipitation which is frequently observed to take place from hitherto stable cloud masses. An example of this is again the summer shower which (as we all know from personal experience) will often release abundant precipitation with little warning.

The theory is based on the physical fact that at temperatures below freezing the saturation vapor pressure with respect to ice is less than that with respect to water. It is an observed fact that in the atmosphere liquid water droplets exist at temperatures far below the freezing point; they have been found to exist at temperatures as low as $-20°C$. Now if in some manner or other, ice crystals are introduced into a cloud consisting of supercooled cloud droplets, i.e. a cloud of liquid water droplets at temperatures well below freezing, the ice crystals will grow at the expense of the droplets by virtue of the lower vapor pressure over ice. Once the ice

crystals grow large enough to acquire a fall velocity (snowflakes) further growth is assured as long as the cloud is of sufficient depth. It matters not if the snowflakes melt, for they will then become rain drops. In fact a large amount of rain during the cold season results from snowflakes melting in the last few hundred feet of their fall. Since this theory postulates the presence of ice-crystals, it is necessary to explain how these may be formed.

First however, we must introduce another type of nucleus, a non-hygroscopic one this time, called a sublimation nucleus. This does not act as a condensation nucleus but it has a shape and size suitable for the formation of ice crystals by sublimation of water vapor. It is presumed that when a cloud is cooled sublimation will occur on these nuclei at temperatures of from −10°C. to −20°C., and that these crystals once formed will grow at the expense of other droplets of a cloud which may eventually evaporate completely leaving only trails of ice crystals, the familiar Mares' Tails so frequently seen preceding a storm. This process probably goes on above a precipitation area. The ice crystals fall slowly downward into the lower cloud layers where the process is repeated until real precipitation is produced. In this connection I might mention the recent experiment conducted by members of the General Electric research staff. This consisted of dropping particles of "dry ice" into a stable cloud mass from above and causing a very little, but nevertheless real, precipitation to fall out of the cloud. This follows the principles set forth in this theory just explained.

There are also two other means by which ice crystals can be introduced into a supercooled cloud: (1) It is possible for some of the supercooled droplets to pick up nuclei of crystallization (sublimation) by collision and become ice crystals. A modified example of this is the formation of rime, a crystalline ice formation on all exposed surfaces in clouds at below freezing temperatures, such as on airplanes. (2) Collisions between supercooled droplets would presumably also cause crystallization, just as stirring of supercooled water will cause crystallization.

In summarizing, we have seen how raindrops are formed as a result mainly of collision between drops of different sizes, except for rain from melting snowflakes. This requires the presence in close proximity of drops of unlike size. These may result from: (1) The presence of extremely large hygroscopic nuclei of condensation. (2) Turbulent mixing within the cloud. (3) Growth of crystals by sublimation at the expense of supercooled liquid drops. The latter is of primary importance in explaining the growth of snowflakes.

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I urge that our leaders of industry and finance make their views known on this need before we talk of tax reduction.

I urge that our leaders of labor, who are talking of further wage demands, give first priority instead as citizens to raising the salaries of the teachers of children.

HAROLD E. STASSEN

## THE SIGNS OF TRIGONOMETRIC FUNCTIONS AGAIN

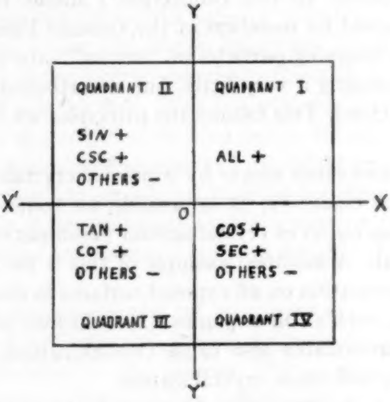
Raymond Horr

*Student at Muskingum, College, New Concord, Ohio*

Please refer to the January issue of School Science and Mathematics, pp. 81–82. The article: The Signs of the Trigonometric Functions of Any Angle, by Grace Marie Coleman.

I hope that I may take the liberty of submitting a device which I learned while studying trigonometry in the Army. Not as a criticism of Miss Coleman, but rather what I think is a much easier and simpler method.

In Miss Coleman's illustration one must depend almost entirely on memorization, while in the accompanying figure there is a device for remembering the device. When one learns the trigonometric functions, or sees then all together in print, they are always arranged in a certain order. That is: sin & cos, tan & cot, sec & csc. So that one usually retains the impression of them in that order. Switch only cs and cos in this order, then starting with the second quadrant (because all are positive in the first quadrant), place a pair of functions in each of the three remaining quadrants in the order mentioned. These functions will be positive; all others negative in each respective quadrant.

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## A NEW TYPE OF SPECTROMETER

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# PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
*State Teachers College, Kirksville, Mo.*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.*

*All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor* should have the author's name introducing the problem or solution *as on the following pages.*

*The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.*

## SOLUTIONS AND PROBLEMS

**Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.**

**1. Drawings in India ink should be on a separate page from the solution.**

**2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.**

**3. In general when several solutions are correct, the ones submitted in the best form will be used.**

## LATE SOLUTIONS

**2006.** *Orville F. Barcus, Philadelphia, Pa.*

**2006, 8.** *Martin Pearl, Brooklyn, N. Y.*

**2006, 7, 9, 10.** *V. C. Bailey, Evansville, Ind.*

**2007.** *W. R. Smith, Sutton's Bay, Mich.*

**1999, 2000, 1, 2, 4, 6, 7, 9, 10.** *Walter R. Talbot, Jefferson City, Mo.*

**2010.** *Sister Mary Paula, Baltimore; Abraham L. Epstein, Asbury Park, N. Y.; Joseph Lerner, Roxbury, Mass.; Felix John, Philadelphia, Pa.*

**2007.** *F. L. Maxwell, Greer, S. C.*

**2000, 4, 10.** *M. Kirk, Norristown, Pa.*

**2004, 6, 7.** *Orville A. George, Mason City, Ia.*

**2011.** *Proposed by Hugo Brandt, Chicago, Ill.*

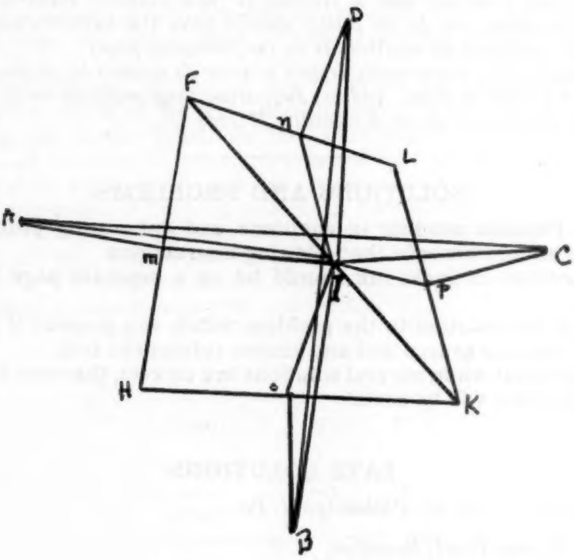
Let $FHKL$ be any quadrangle with $A, B, C, D$ the centers of 4 squares erected on sides $FH, HK, KL, LF$, respectively. Show that $AC$ and $BD$ are perpendicular to each other and that $AC = BD$.

*Solution by E. de la Garza, Brownsville, Texas*

Join $A, B, C, D$ to the middle, $I$, of the diagonal $FK$. Also join to $I$ the middle points $m, n, o, p$ of the four sides of the quadrangle. Join $AC$ and $BD$.

In triangles $ICp$, $IDn$, $Ip$ and $Dn$ are equal and perpendicular ($Ip$ equal and parallel to $Ln$ and $Ln$ and $Dn$ equal), and $Cp$, $In$ are also equal and perpendicular ($Cp$ equal $Lp$ and $Lp$ equal and parallel to $In$). Hence, $CI$ and $Di$ are equal and perpendicular.

In triangles $IBo$, $IAm$, $Io$ and $Am$ are equal and perpendicular ($Io$ equal and parallel to $mH$ and $mH$ and $Am$ equal), and $Bo$, $Im$, are also equal and perpendicular ($Bo$ equal $oH$ and $oH$ equal and parallel to $Im$). Hence, $BI$ and $AI$ are equal and perpendicular.




In triangles $AIC$ and $DIB$ we have $CI$ and $DI$ and $AI$ and $BI$ equal and perpendicular to the third sides, $AC$ and $BD$, are consequently also equal and perpendicular.

Solutions were also offered by Francis L. Miksa, Aurora and by the proposer.

**2012.** *Proposed by Martin Pearl, Brooklyn, N. Y.*

From an external point, $P$, two tangents are drawn to a circle at $A$ and $B$. Secant $PCD$ cuts the circle at $C$ and $D$. Chord $AB$ is drawn with midpoint $M$. $CME$ cuts the circle at $E$. Prove $DE$ is parallel to $AB$.

*Solution by Clifford Spector, Bronx, N. Y.*

Draw a line through points $P$ and $M$. It can be proven that $PGM$ is perpendicular to $AB$, and, if extended to $F$, will pass through the center of the circle, $O$. From $O$ draw radii $OB$ and $OC$.

Since a tangent is perpendicular to the radius drawn to point of contact, triangle $POB$ is a right triangle with altitude $BM$ on the hypotenuse.

$$\therefore \quad \frac{OM}{OB}=\frac{OB}{OP}. \tag{1}$$

Radii $OB$ and $OC$ are equal.

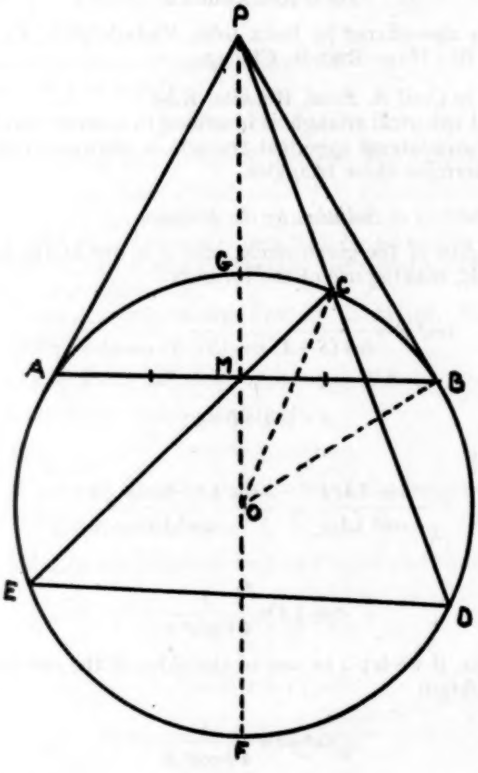
(2) $$\therefore \quad \frac{OM}{OC} = \frac{OC}{OP}.$$

It follows that

(3) $$\triangle OMC \sim \triangle OPC$$

(4) $$\therefore \quad \angle OPC = \angle MCO$$

(5) $$\angle OPC \overset{M}{=} \tfrac{1}{2}(\widehat{FD} - \widehat{GC}).$$




Arc $GC$ is measured by angle $POC$.

(6) $$\therefore \quad \angle OPC \overset{M}{=} \tfrac{1}{2}(\widehat{FD} - \angle POC).$$

It follows that

(7) $$\widehat{FD} \overset{M}{=} 2\angle OPC + \angle POC.$$

Exterior angle $OCD$ of triangle $POC$ equals angle $POC$ plus angle $OPC$.

(8) $$\therefore \quad \angle ECD = \angle MCO + \angle POC + \angle OPC.$$

Inscribed angle $ECD$ is measured by $\frac{1}{2}$ its intercepted arc $\widehat{EFD}$.

(9) $$\therefore \quad \angle MCO + \angle POC + \angle OPC = \tfrac{1}{2}\widehat{EFD}.$$

Angle $OPC$ equals angle $MCO$ (4).

(10) $\therefore\ \angle MCO+\angle OPC+\angle POC=2\angle OPC+\angle POC.$

Substituting (7) and (9) in (10), we have

(11) $\widehat{FD}=\frac{1}{2}\widehat{EFD}$ or $\widehat{EF}=\widehat{FD}.$

A radius bisecting a chord's arc is perpendicular to the chord.

(12) $\therefore\ PF\perp ED.$

Since $AB$ and $ED$ are both perpendicular to $PF$, therefore

(13) $DE$ is parallel to $AB$.

Solutions were also offered by Felix John, Philadelphia, Pa.; Francis L. Miksa, Aurora, Ill.; Hugo Brandt, Chicago.

**2013.** *Proposed by Cecil B. Read, Wichita, Kan.*

An equilateral spherical triangle is inscribed in a given small circle on a sphere; also an equilateral spherical triangle is circumscribed about the same circle. Determine these triangles.

*Solution by the proposer*

If $R$ is the radius of the given circle, and $A$ is one of the angles of the inscribed triangle, making use of the formula

$$\tan^2 R=\frac{-\cos S}{\cos(S-A)\cos(S-B)\cos(S-C)}$$

where

$$S=\tfrac{1}{2}(A+B+C)$$

which reduces to

$$\frac{-\cos 3A/2}{\cos^3 \frac{1}{2}A}=\frac{3\cos\frac{1}{2}A-4\cos^3\frac{1}{2}A}{\cos^3\frac{1}{2}A}$$

we obtain

$$\cos^2\tfrac{1}{2}A=\frac{3}{4+\tan^2 R}\,.$$

In like manner, if we let $a$ be one of the sides of the circumscribed triangle, we may obtain

$$\sin^2\tfrac{1}{2}a=\frac{3}{4+\cot^2 R}\,.$$

Hugo Brandt, Chicago also offered a solution.

**2014.** *Proposed by Lillian A. MacDonald, Newark, N. J.*

If $S_p$ is the sum of the $p$th powers of the first $n$ odd integers, show that $S_7+7S_5+7S_3+S_1$ equals the fourth power of an integer.

*Solution by Norman Auning, University of Michigan*

Using the well known general formula for finding the $p$th powers of the first $n$ integers,

$$S_n=\frac{n^{p+1}}{p+1}+\frac{n^p}{2}+B_1\frac{p}{2!}n^{p-1}-B_3\frac{p(p-1)(p-2)}{4!}n^{p-3}+\cdots,$$

where $B_1=\frac{1}{6}$, $B_3=1/30$, $B_5=1/42$, etc., one obtains

$$S_7=(48n^8-112n^6+98n^4-31n^2)/3.$$
$$S_5=(16n^6-20n^4+7n^2)/3.$$
$$S_3=2n^4-n^2.$$
$$S_1=n^2.$$
$$S_7+7S_5+7S_3+S_1=16n^8=(2n^2)^4,$$
$$=\text{fourth power of integer.}$$

Other solutions were offered by Hugo Brandt, Chicago; Felix John, Philadelphia, Pa.; Francis L. Miksa, Aurora, Ill.; M. M. Dreiling, Collegeville, Ind.

**2015.** *Proposed by Hugo Brandt, Chicago, Ill.*

Find values of $x$ to satisfy

$$x^5\equiv 1 \pmod{11}.$$

*Solution by Clarence R. Perisho, McCook, Neb.*

If we let $y^2=x$, we have $y^{10}\equiv 1$ (mod 11). From Fermat's theorem we learn that this is always true if 11 is prime number (which it is) and is not a factor of $y$. The equation is satisfied then by all values of $y$ except multiples of eleven. Values of $x$, which satisfy the equation are then all perfect squares except multiples of 11.

Solutions were also offered by Francis L. Miksa, Aurora, Ill.; Hugo Brandt, Chicago.

**2016.** *Proposed by Helen M. Scott, Baltimore, Md.*

For the closed curve represented by

$$(x/a)^2+(y/b)^{1/n}=1.$$

Where $n$ is an integer, find the coordinates of the points of inflexion.

*Solution by Francis L. Miksa, Aurora, Ill.*

Points of inflexion are found by finding $d^2y/dx^2$ and equating this to zero. We have

$$(x/a)^2+(y/b)^{1/n}=1. \tag{1}$$

Solving for $y$

$$y=b\left[(a^2-x^2)/a^2\right]^n \tag{2}$$

$$dy/dx=bn/a^{2n}(-2x)\left[\frac{(a^2-x^2}{a^2}\right]^{n-1} \tag{3}$$

$$d^2y/dx^2=\frac{nb}{a^{2n}}(-2)\left[\frac{(a^2-x^2)}{a^2}\right]^{n-1}+\frac{nb}{a^{2n}}(-2x)(-2x)(n-1)\left[\frac{(a^2-x^2)}{a^2}\right]^{n-2} \tag{4}$$

$$d^2y/dx^2=0 \tag{5}$$

$$\left[(a^2-x^2)/a^2\right]^{n-2}\left[4x^2(n-1)-2(a^2-x^2)\right]=0. \tag{6}$$

Second factor becomes

$$(2n-1)x^2=a^2$$
$$x=\pm a/\sqrt{(2n-1)}.$$

Putting this value of $x$ in (1) we get

$$y=b\left[(2n-2)/(2n-1)\right]^n. \tag{8}$$

The proposer also offered a solution.

## HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

**2012.** *Clifford Spector, Martin Pearl, New Utrecht High School, Brooklyn, N. Y.*

## PROBLEMS FOR SOLUTION

**2035.** *Proposed by Orville F. Barcus, Philadelphia, Pa.*

Show without actually performing the division that $2^{2^6}+1$ has the factor 641. Error see p. 660

**2036.** *Proposed by Roy Dubisch, Missoula, Mont.*

An arithmetic series with $a$ as first term and $d$ as common difference coincides with the first three terms of a geometric series with $a$ as first term and $r$ as ratio. Find the series.

**2037.** *Proposed by Joseph A. Nyberg, Chicago.*

Show that a great circle arc is in general not a rhumb line.

**2038.** *Proposed by Arthur Porges, Los Angeles, Calif.*

Find the $r$th term and the sum of $8r$ terms of the infinite series

$$4+16x+37x^2+58x^3+89x^4 \cdots +a_rx^{r-1}.$$

**2039.** *Proposed by Belle Conley, Newark, N. J.*

Resolve into factors $a^4(b-c)+b^4(c-a)+c^4(a-b)$

**2040.** *Proposed by Albert Hansen, Minneapolis, Minn.*

Prove that $x^2-3y^2=17$ has no integral solution.

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## IMPORTANT FOR OUR CHILDREN

### Harold E. Stassen

The 1943 total expenditures by all levels of government for education was actually less than the preceding year's expenditure and, at 2.3 billions of dollars, represented only a small fraction of our total expenditures of all types for government.

We realize full well that dollars are not the only reason that men and women follow the noble profession of teaching. We realize full well the deep satisfaction that hundreds of thousands of our fellow citizens obtain from teaching the youth of the land.

But no nation that is prosperous and civilized and free can afford to neglect the economic standing of its teachers in relationship to its other occupations.

# BOOKS AND PAMPHLETS RECEIVED

SCIENCE SINCE 1500. A Short History of Mathematics, Physics, Chemistry, Biology, by H. T. Pledge, *Librarian, Science Museum of London.* Cloth. 357 pages. 15 c 24 cm. 1947. Philosophical Library, 15 East 40th Street, New York 16, N. Y. Price $5.00.

BASIC MATHEMATICS FOR TECHNICAL COURSES, by Clarence E. Tuites, *Instructor in Electricity and Mathematics, Rochester Institute of Technology.* Cloth. Pages xiv+343+132. 14.5×23 cm. 1947. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.00.

ADVANCED MATHEMATICS FOR ENGINEERS, by H. W. Reddick, *Adjunct Professor of Mathematics, New York University, University Heights;* and F. H. Miller, *Professor and Head of the Department of Mathematics, The Cooper Union School of Engineering.* Second Edition. Cloth. Pages xii+508. 13.5×21 cm. 1947. John Wiley and Sons, 440 Fourth Avenue, New York 16, N. Y. Price $5.00.

ELEMENTS OF SOIL CONSERVATION, by Hugh Hammond Bennett, *Chief Soil Conservation Service, U. S. Department of Agriculture.* Cloth. Pages x+406. 13.5×20.5 cm. 1947. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $3.20.

CHEMISTRY FOR OUR TIMES, by Elbert Cook Weaver, M. A., *Instructor, Phillips Academy, Andover, Massachusetts;* and Laurence Standley Foster, Ph.D., *Formerly Assistant Professor of Chemistry, Brown University, Chief, Powder Metallurgy Branch, Research Division, Laboratory Department of the Watertown Arsenal, Watertown, Massachusetts.* Cloth. Pages xii+738. 15×22.5 cm. 1947. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York 18, N. Y. Price $2.48.

COSMIC RADIATION. Fifteen Lectures Edited by W. Heisenberg, and Translated by T. H. Johnson. Cloth. 192 pages. 15×23.5 cm. 1946. Dover Publications, 1780 Broadway, New York 19, N. Y. Price $3.50.

TELEVISION SIMPLIFIED, by Milton S. Kiver. Cloth. Pages vii+375. 13.5×20.5 cm. 1946. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York 3, N. Y. Price $4.75.

NEW WORLD OF CHEMISTRY, by Bernard Jaffe, *Chairman, Department of Physical Science, James Madison High School, New York City.* Cloth. Pages x+710. 15×22.5 cm. 1947. Silver Burdett Company, 45 East 17th Street, New York 3, N. Y. Price $2.88.

ANALYTIC GEOMETRY, by Frederick H. Steen, Ph.D., *Professor of Mathematics, Allegheny College,* and Donald H. Ballou, Ph.D., *Assistant Professor of Mathematics, Middlebury College.* Second Edition. Cloth. Pages vii+234+10. 14.5×22 cm. 1946. Ginn and Company, Statler Building, Boston, Mass. Price $2.50.

COLLEGE ALGEBRA, by Thurman S. Peterson, Ph.D., *Associate Professor of Mathematics, University of Oregon.* Cloth. Pages viii+334. 12.5×20 cm. 1947. Harper and Brothers, 49 East 33rd Street, New York 16, N. Y.

THE METHODS OF PLANE PROJECTIVE GEOMETRY BASED ON THE USE OF GENERAL HOMOGENEOUS COORDINATES, by A. A. Maxwell, *Fellow of Queens' College, Cambridge.* Cloth. Pages xix+230. 13×22 cm. 1946.

Cambridge University Press, The Macmillan Company, 60 Fifth Avenue, New York 11, N. Y. Price $2.75.

VITALIZED GENERAL SCIENCE, by Barclay M. Newman, *Formerly Head of Science Department, Brooklyn Academy, Brooklyn, N. Y.* Edited by Sebastian Haskelberg, *Department of Science, James Fenimore Cooper Junior High school, New York City;* and Esther Boal, *Department of Science, Emerson High School, Gary, Indiana.* Paper. Pages iv+380. 12.5×18.5 cm. 1947. College Entrance Book Company, Inc., 104 Fifth Avenue, New York 11, N. Y. Price 75 cents.

ONE WORLD IN SCHOOL. A Bibliography, by Louella Miles, *Chairman, School Committee, Saint Paul Council of Human Relations.* Paper. Pages ix+58. 15×23 cm. 1946. The American Teachers Association, P. O. Box 271, Montgomery 1, Alabama. One to five copies five cents each.

TRENDS IN AMERICAN PROGRESS. Facts and Figures about the Growth of Economic Life in America. Paper. 67 pages. 21×28 cm. Investors Syndicate, Minneapolis, Minn.

## BOOK REVIEWS

OUR BIG WORLD, by Harlan H. Barrows, *Department of Geography, University of Chicago,* Edith Putnam Parker, *Department of Geography, University of Chicago,* and Clarence Woodrow Sorensen, *Traveler and Geography Lecturer.* Cloth. Pages vl+186. 21.5×27.5 cm. 193 Figures,—maps, sketches and photographs. Drawings by Milo Winter. 1946. Silver Burdett Company, New York, Chicago and San Francisco. List Price $1.80.

*Our Big World* is the first in a series of new elementary geography texts entitled *Man In His World.* This book is designed for the 4th Grade. It is simply written and attractively illustrated with well chosen photographs and many excellent sketches in color and black and white. The book is abundantly supplied with actual globe photographs, over half of which are in color, and with many simple maps. The Index with Key to Pronunciation furnishes easy reference.

The pictures and maps have simple, brief captions. The clear explanatory style of the text leads the child into pictures and maps, and shows him how these tools are used by making them a natural part of the presentation. At frequent intervals the child is given opportunity to explore by himself. At such times he uses pictures, maps and globes to find reasons, to discover relationships and to answer questions.

A simple world understanding is developed through a consideration of people in a variety of places, each confronted with the problems of living. Iceland, Norway, the Netherlands, Switzerland, Mediterranean Lands, the Sahara and the Nile, Land of the Congo and Australia furnish a series of settings. The child becomes acquainted with life in high lands and low, wet lands and dry, lands far north and lands far south. The presentation is such that he moves quickly from place to place, having his attention called to significant and interesting things, to things that can be related to place, in which they are found.

Having traveled from the far north to the south, a survey of places from Australia to the Arctic and from Alaska to Cape Horn furnishes contact with other areas and opportunity to contrast them with places previously visited.

In the course of a year the child visits all continents and all oceans, and acquires a simple understanding of the world. He acquires skill in the use of simple maps and globes. He acquires a simple and fundamental vocabulary and the ability to use it in expressing ideas.

The book is substantially bound. It is printed in clear type on good paper.

VILLA B. SMITH
John Hay High School, Cleveland Ohio

THE AMERICAN CONTINENTS, by Harlan H. Barrows, *Department of Geography, University of Chicago,* Edith Putnam Parker, *Department of Geography, University of Chicago,* and Clarence Woodrow Sorensen, *Special Lecturer in Geography, Community Program Service, University of Minnesota.* Cloth. Pages v+314. 21.5×27.5 cm. 268 Figures,—maps, sketches and photographs. Drawings by Milo Winter. 1946. Silver Burdett Company, New York, Chicago and San Francisco. List Price $2.24.

The American Continents is the 5th Grade text in the *Man In His World* series of elementary geographies. Fully two thirds of the book deals with the United States, one third with Canada and Latin America. The text puts real meaning into the geography of present day United States by presenting a most interesting series of chapters dealing with the historical geography of the nation. This historical presentation takes the student from the Atlantic to the Pacific, and provides the background for present day activities which are the better understood in terms of their early beginnings.

In the section Beyond the States, the student is introduced to Alaska, the Hawaiian Islands, Midway, Wake and Guam, the Commonwealth of the Philippines, Puerto Rico, the Virgin Islands and the Canal Zone. The presentation of Canada and Latin America is brief. In a simple, yet masterful way, the fundamental geography of these nations is presented. The 5th Grade student is not confronted with a mass of detail, but with a geographic interpretation within his comprehension. Upon such a foundation later detailed study can be based.

The book is attractively illustrated with over one hundred drawings, seventy-five of which are in color, and with over one hundred excellent and well chosen photographs some of which are air views. The book is liberally supplied with maps. The physical maps are large and with colors that are distinct. The dot maps are larger than usually found in elementary texts and consequently easier to read. Sketch maps, giving detailed information concerning small areas, such as, The Central Valley of California, The Oregon Country, New Orleans, on the lower delta etc., are plentiful and most helpful. Maps showing precipitation, natural resources etc., appear at places where they best serve in the interpretation of areas.

The 5th Grade child should find the text easy to read and its style entertaining. The sentences are short and the vocabulary adjusted to his reading level. The descriptive narrative carries him along and develops ideas unobscured by details. Maps and pictures are a functioning part of the text, used where they best serve.

The typography is excellent. The binding is substantial. The paper of good quality.

VILLA B. SMITH

CHEMISTRY AND HUMAN AFFAIRS, by William E. Price, *Department of Chemistry, Clifford J. Scott High School, East Orange, New Jersey,* and George H. Bruce, *Late of Horace Mann School for Boys, Teachers College,*

*Columbia University, New York.* Cloth. Pages xii+788. 14.5×22.5 cm. 1946. World Book Company, Yonkers-on-Hudson, N. Y. Price $2.68.

The publishers claim that this book "follows a middle road between the strictly college preparatory path on one side and the applied, or consumer-type, on the other."

Advocates of both schools will hope that this does not mean that the authors have avoided both functions but that they have attempted to encompass both goals. Inspection of the book's content and organization reveals that the emphasis in the first part at least has been primarily in the direction of the so-called college preparatory course-of-study. The book throughout contains many illustrations and statements about the applications of chemistry principles in industry and everyday life and the consumer education advocate will find that the latter chapters tend to be organized around these practical applications and occurrences.

In an effort to make the book sufficiently complete and yet not include material that the consumer education teacher would consider too difficult, the authors have selected the Appendix as a place in which to file the material that is sufficiently difficult to demand some mathematical ability. They could never hope to satisfy everyone that they had selected the proper things to include in the Appendix and probably most everyone will think that they have left in the text a few topics much too difficult and more unimportant than some which have been filed away in the Appendix.

The general organization of the text is well executed being divided into 17 units each having from 4 to 8 sub-units or problems. Each unit is introduced by a page or so of introductory comment written in the first-person. Each problem is concluded with a "summary guide" consisting of questions that the student can use to test his own mastery of the problem. The Unit itself is concluded with an overall group of questions labeled, "applying what you have learned." Suggested outside readings are included at the end of each unit and these are from the Journal of Chemical Education, Collateral Readings in Organic Chemistry, and Collateral Readings in Inorganic Chemistry. In all cases, the length of these reading assignments is given in minutes.

The book is profusely and expertly illustrated with both photos and sketches. A few sketches of a semi-cartoon nature are included but unfortunately these latter ones fall a bit short of fulfilling their purpose and attaining the high standards of the other drawings. One of these appearing twice in the text will cause the chemist some concern when he reads the following question caption under a picture showing the bride, groom, and minister at the altar: "Which of the three persons in this marriage ceremony can be regarded as the catalyst?"

Most sections of the text are well done and sufficiently complete. This text should perform very satisfactorily the textbook function in any college-preparatory chemistry course and should be a useful supplement to most consumer science courses.

SCHAILER PETERSON

SCIENCE IN A CHANGING WORLD, by Emmett James Cable, Ph.D., *Head of the Science Department;* Robert Ward Getchell, Ph.D., *Professor of Chemistry;* and William Henry Kadesch, Ph.D., *Professor of Physics, Iowa State Teachers College.* Revised Edition. Cloth. Pages xvii+622. 14.5×23 cm. 1946. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $5.00.

This is a revised edition which has been brought up-to-date. This book might serve as a textbook for a somewhat advanced general science course

or it might on the other hand provide informative reading for the citizen who wants an overview of all the major fields of science. The book is composed of forty-three chapters that cover almost everything. Those who are competent in the fields covered by these chapters will discover that the writer or writers have been very skillful in excluding the excess explanatory "baggage" and reduced the content to a very minimum. The lay reader or student would never learn to write chemical formulas or to balance equations from these abbreviated discussions whereas he probably would be able to understand the operations of Boyle's Law.

The book appears a bit inconsistent, including some seemingly unimportant points for a book of this kind. This might be the result of "too many cooks" or in this instance, "too many authors" editing the manuscript and insisting upon slipping in or adding "just this one more item to make it complete." The book becomes almost an encyclopedia or perhaps a dictionary of science, or some comments while considered by the authors as justification for inclusion in the index are too brief to be at all helpful, as for example the "atomic bomb." The subject "radar" on the other hand, while brief is given meaning.

The authors in places have used catchy phrases for sectional headings such as "The outlaw progeny of nitrogen"; "Sparklers"; "Water, water, everywhere"; "Notorious fluorine"; etc. These are perhaps more the exception than the rule for most of the headings are much more conventional. The chapters have no "question-answer" sections and there are no reference lists. Therefore the teacher will not find the usual textbook devices or aids. However, a resourceful teacher should be able to build an interesting advanced general science course around this book's basic content. For general, non-school reading the book should provide excellent reading.

SCHAILER PETERSON

AN INTRODUCTION TO COLLEGE MATHEMATICS, by Carroll V. Newsom, *Head of Department of Mathematics, Oberlin College.* Pages vii+344. 15×23 cm. 1946. Prentice-Hall, Inc., 70 Fifth Avenue, New York 11, N. Y. Price $3.50.

A new text in the growing field of those attempting to provide adequate mathematical instruction for the non-science liberal arts college student.

Topics are included from the field of elementary mathematics so as to form the basis of a year course of three hours credit for each semester. Students are recommended to have a minimum of two years of high school mathematics.

The author states in his preface that the content has been selected on the basis of student needs. His selection possibly may be questioned in several instances, but the result has been a unified sequence of materials.

The first half of the book deals with the nature of mathematics, the number concept, and fundamental operations of arithmetic, with several topics from algebra. The last half develops related topics in functional relations, variation, trigonometry, analytic geometry, and statistics. All of the material is well integrated and definitely not in the traditional departments, so that a continuous flow of learning is presented to the student. Emphasis is laid upon understanding, rather than manipulative and technical skill. General formulas, usually taught for solution purposes, are not used as such, but are developed as student exercises in generalization. A strong relation is held between theory and application, with exercises being presented at logical points in the discussion. An aid to the instructor would have been the inclusion of references to supplementary materials.

In general this book seems not to be an introduction or survey in the

usual sense of the word, but rather a "hind-sight," since most of the material will have been experienced previously by the student.

This book will warrant investigation not only as a possible text for a course as suggested by the author, but also as a lesson in the presentation of a logical, well organized content of meaningful mathematics.

W. K. McNabb
Hockaday Junior College, Dallas, Texas

The Development of Trigonometry from Regiomantanus to Pitiscus, by Sister Mary Claudia Zeller of the *Sisters of St. Francis of Mary Immaculate, Joliet, Illinois.* Paper. Pages vii+119, 21×27 cm. 1946. Edwards Brothers, Inc., Ann Arbor, Michigan.

A doctoral dissertation tracing the historical development of trigonometry from its original position as a computational aid to astronomy to its modern day status as an independent mathematical subject.

Particular emphasis is given to the fifteenth to seventeenth century period of flourishing growth. The principal trigonometric works of this interval are discussed in great detail in the light of their contributions to the development of the subject and in relation to previous efforts. Many illustrations are used and forty plates depicting original works are included. A tabular summary is shown of basic terminology and notation as used by prominent authors. A complete bibliography is given.

This work should be of interest to the teacher and student of mathematics not only for the many interesting developments and applications of familiar (and sometimes not so familiar!) items from geometry and trigonometry, but also for the general overall view that is given to the subject of trigonometry.

W. K. McNabb

Tables of Associated Legendre Functions is one of nineteen volumes prepared by the Mathematical Tables Project, under the supervision of Dr. A. Lowan. It consists of 303+xlvi pages, contains seventeen tables, and can be purchased from the Columbia University Press of New York, at $5 per copy.

These tables were begun by the Work Projects Administration, and continued by the Applied Mathematics Panel of the National Defense Research Committee. They were at first designed to assist in the war effort, but because of their value in engineering and many other problems of a practical nature not connected with war, they have since been completed, and contain a total of eighteen tables.

The values of $P_n^m(x)$, $Q_n^m(x)$, the Associated Legendre Functions, together with their first derivatives, are tabulated for integral values of $m$, integral and half-integral values of $n$, and for real and imaginary values of $x$; also those of $P_n^m(\cos\theta)$ and their first derivatives with respect to $\theta$ for integral values of $m$ and $n$.

Much time and labor were saved by computing all Legendre Functions except the fundamental ones given above by means of recurrence formulas whereby values of $U_n^m$ may be found from those of $U_{n-1}^m$ and $U_{n-2}^m$, or from those of $U_r^{m-1}$, $U_n^{m-2}$, and $U_{n+1}^{m-1}$, $U$ indicating either $P$ or $Q$, the Associate Legendre Functions of the first and second class, respectively.

The values of $U_{n-1}^m$, $U_{n-2}$, $U_n^{m-1}$, $U_n^{m-2}$, which were pre-computed, are known as key values.

In computing the key values of $P_n^m$ those of the so-called Legendre Polynomials were made use of but for those of $Q_n^m$ hypergeometric series were used.

Throughout the development of the tables the questions of convergence, limiting values of the different variables, accuracy obtainable under different conditions and labor involved, keep recurring as they needs must in any extended computation, as a series may be convergent and yet converge so slowly that, in order to obtain the required degree of accuracy, it may be necessary to carry the computation to so many terms of the series that the amount of work necessary may be prohibitive. These problems have all been fully considered and apparently solved in a way to result in the computation of the tables with the maximum degree of accuracy and a minimum expenditure of energy, which in any event was a stupendous amount.

In addition, many values were computed by different formulas, thus giving valuable checks on the accuracy of the results, a very desirable and well-nigh indispensable consideration in an undertaking of this magnitude.

A very extensive bibliography is included, containing some very rare papers and texts as well as some of those which are readily available.

A very valuable piece of work seems to have been accomplished in a most satisfactory manner, one which will be a very valuable addition to the great body of tables now available.

W. E. Anderson
Professor of Mathematics, Miami University

The Magic Numbers, by Eric Temple Bell, Author of *Men of Mathematics*. Cloth. Pages viii+418. 13.5×20.5 cm. 1946. Whittlesey House, McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $3.50.

In the first chapter of this book Dr. Bell points out a sharp disagreement in the underlying philosophy of present day mathematicians and physicists. One group, following Newton and other leaders of the seventeenth and eighteenth centuries, believe that reliable knowledge of the physical universe cannot be obtained except by combining mathematics with precise observation and purposeful experiment. The other school of thought, starting about the year 1920, began to take the reverse of this position, retreat from experiment to reason, and adopt the mystic doctrine of Pythagoras—Everything is Number; in other words, by taking sufficient thought the scientist might rediscover, without recourse to experiment, all that we consider fundamental laws, to say nothing of obtaining knowledge of phenomena which are still obscure to science.

Although it is obvious that the author is not completely sympathetic with this "return to the remote past," the book is written with the idea of seeing the historical background of the manner in which the differences of opinion came about. Whether or not one is interested in the merits of this particular question, the book itself is an entrancing history of the development of much of the history of mathematical thought. Indeed, once one has started it is hard to lay the book down. As might be expected, a major portion of the book is devoted to Pythagoras and his associates. However, there are many other giants of mathematics who enter the picture for consideration. The Egyptians and the Babylonians, Thales, Anaximander, Empedocles, Zeno, Plato, St. Augustine, John Dee, Robert Recorde, Roger Bacon, Galileo, Newton, Berkeley, Saccheri, Kant, Lobachewsky, Einstein—these and many others pass more or less briefly before the reader as the author traces the development of these conflicting philosophies.

No mathematical knowledge is needed in order for one to read and enjoy this text. One may appreciate how some men won fame in their own time,

how others had to fight the tyranny of ignorance, how still others together with their contemporaries failed to realize the true value of what they had discovered. Much of the material is indeed thought provoking—in fact the very existence of these conflicting views is probably not widely known. The style of writing is excellent, occasional examples of the author's dry wit will leave the reader chuckling; one enjoys the idea of Pythagoras and Plato returning as shadowy figures to discuss developments in 1600, or as uninvited judges of a debate in the twentieth century. Again, one can not help but appreciate the parallel between the theological question of the number of angels who can dance on the point of a needle and mathematical problems arising from consideration of the infinite.

This book should be read by every physical scientist and mathematician, it would be a welcome addition to college and high school libraries. The reviewer has only one minor criticism—an index might be an addition.

CECIL B. READ
University of Wichita

PRACTICAL ELECTRICAL MATHEMATICS, by William Edward Rasch, M.A., *Teacher, Electrical Department, Washburne Trade School, Chicago, Illinois.* Cloth. Pages viii+360. 12.5×18.5 cm. 1946. D. C. Heath and Company, 285 Columbus Avenue, Boston 16, Mass. Price $2.00.

This is a text designed to furnish the mathematical training necessary for one learning the electrician's trade. The assignments are, in the words of the author, designed to "parallel the schedule of work processes customarily followed in learning the trade."

Each assignment contains a brief discussion of the theory involved, preceded by questions intended to start the student thinking. After illustrative examples, problems are given, which seem well graded as to difficulty. Answers are provided to some of the easier problems. An introductory statement, "To the Student," is exceptionally good.

The text should seem particularly well adapted to trade or apprenticeship classes—it is not a substitute for texts in traditional mathematics courses. However, it should be a fertile source of applied problems, and may provide several answers to a question frequently asked by the student, "What practical use has this material?"

According to the publisher, the author is a journeyman electrician, as well as a successful trade teacher.

There are numerous illustrations. The typography is good although the size of type is small. A minor misprint was noted on page 9.

CECIL B. READ

MATHEMATICIANS' DELIGHT, by W. W. Sawyer, assistant lecturer in mathematics, Manchester University. Paper. Pages 215. 11×18 cm. 1946. Penguin Books, Inc., New York. Price 25¢.

According to the author, "the main object of this book is to dispel the fear of mathematics." Using applications to problems of everyday experience, the author leads the reader through elementary arithmetic, algebra, on through calculus, trigonometry and differential equations. The book is not a text, but might well serve the purpose of telling the student about branches of mathematics he has not yet encountered. With the purpose of the author in mind, one does not expect rigorous treatment, yet the treatment is in general quite sound. It should be quite readable by the general public.

In its inexpensive binding, the book would not stand the usage it would receive in a school library. It is, however, well worth its small cost.

CECIL B. READ